

## **Papers on the mastoid region of the skull / by Ambrose Birmingham.**

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PAPERS

ON THE

MASTOID REGION OF THE SKULL.

I. ITS TOPOGRAPHICAL ANATOMY.

II. GUIDES FOR OPERATING.

*With the Author's  
Comments.*

BY

AMBROSE BIRMINGHAM, M.B.;

PROFESSOR OF ANATOMY, CATHOLIC UNIVERSITY, IRELAND.

Reprinted from the Dublin Journal of Medical Science—February, 1891.

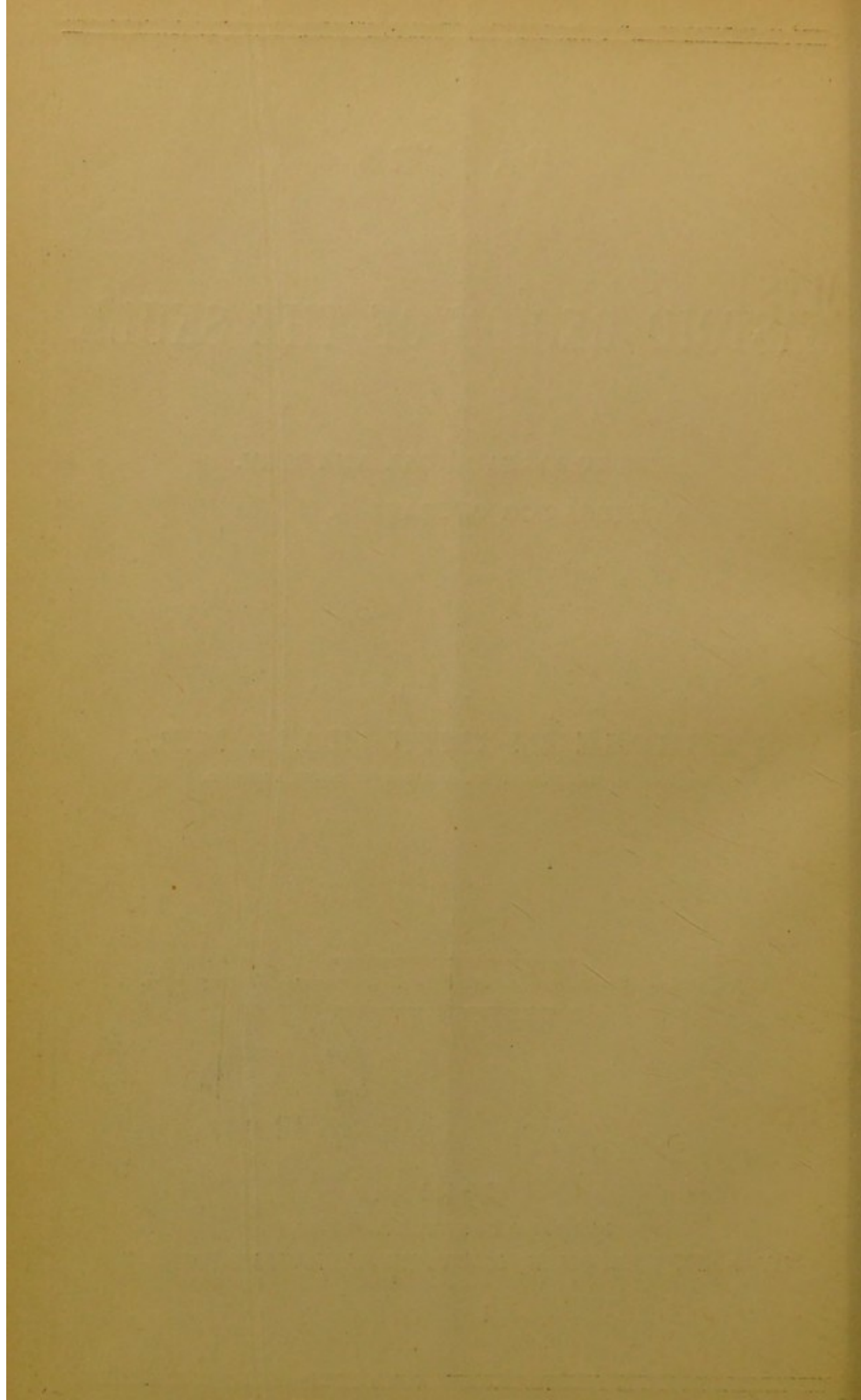


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BY JOHN FALCONER, 53 UPPER SACKVILLE-STREET.

1891.





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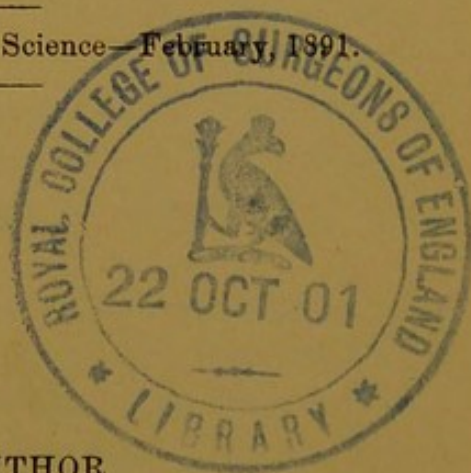
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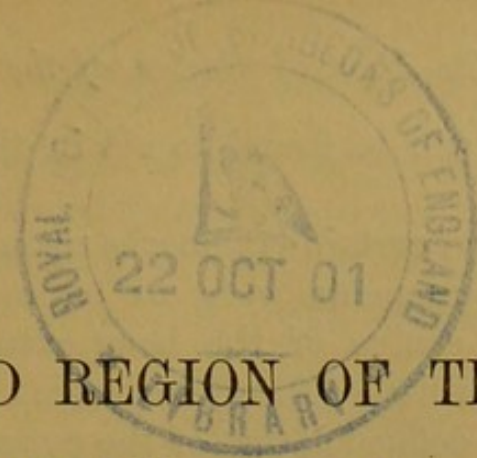
1874

THE HISTORY OF THE

REPUBLIC OF THE UNITED STATES

OF THE UNITED STATES

THE HISTORY OF THE



# THE MASTOID REGION OF THE SKULL,

WITH SPECIAL REFERENCE TO

## OPERATIONS ON THE PART.<sup>a</sup>

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SOME two years ago an important discussion took place in the Royal Academy of Medicine in Ireland upon the operation of trephining in mastoid and tympanic disease. There was chiefly under consideration an operation proposed and practised by Mr. Wheeler, of Dublin, in which the skull was trephined above and behind the ear, the trephine being placed in front of a vertical line dividing the mastoid process, and having its lower margin on the level of the external auditory meatus. By this means, Mr. Wheeler pointed out, the mastoid cells and tympanum might be drained, and the cranial cavity at the same time opened to give exit, if it were found necessary, to intracranial collections of pus. It was urged by those who opposed the operation that if his directions were followed the lateral sinus would be opened into. At the time I was unable to come to a satisfactory conclusion on this point. I knew that the lateral sinus varied to a marked degree in different skulls, both in size and position; and I felt that it would be useless to draw conclusions from the examination of a few specimens, consequently I began to collect material for an investigation into the matter. I have now collected one hundred specimens, and I feel that from an examination of this number some useful conclusions may be arrived at.

Although I started solely with the intention of ascertaining whether the anatomy of Mr. Wheeler's operation was sound or otherwise, as I went along I found that several side issues sprung up, and some of these appeared so important that they were followed with more attention and interest than the original point selected for investigation. It will be better to consider first these

<sup>a</sup> Read before the Anatomical Section of the British Medical Association, 1890.



side issues; they will be found to aid in the solution of the original question.

As a preliminary, certain landmarks upon the skull were chosen from which measurements were to be made. The first point selected was the centre of the bony external auditory meatus. Occasionally it is a little difficult to decide exactly what the centre is, owing to the ill-defined nature of the upper and posterior borders of the meatus; still, a small amount of care will always overcome this difficulty.<sup>b</sup>

Secondly, an easy guide to the horizontal plane was required in specimens of incomplete skulls. This was found in the line of the upper border of the zygoma, which runs practically horizontally forwards in the majority of cases. This will generally be found a useful guide.

A third guide selected was Mr R. W. Reid's "base line," running from the lower margin of the orbit backwards through the centre of the bony external auditory meatus. I examined twenty skulls to find the level of this line posteriorly at the occipital protuberance. The following was the result:—

Base line from $\frac{1}{4}$ to $\frac{1}{2}$ inch below protuberance	-	10
„ from $\frac{1}{4}$ to $\frac{1}{2}$ inch above „	-	4
„ corresponding to protuberance	-	6

I also examined the relations of the base line to the superior curved line. Result:—

Base line below superior curved line	-	-	-	12
„ above „ „	-	-	-	2
Superior curved line, corresponding pretty closely to base line	-	-	-	6

From the foregoing it will be seen that, as a rule, both the external occipital protuberance and the superior curved line lie above the level of the base line to a very slight extent. Half an inch measured here on the surface of the skull means a very small difference of *level*, owing to the almost horizontal position of this part of the cranium, so that the base line may be said to correspond roughly to the protuberance.

<sup>b</sup> The walls of the meatus also vary to a considerable degree, both in surface and direction. In the majority of cases the upper wall is nearly horizontal with a slight slope downwards as its inner part; occasionally this downward slope is well marked. The posterior wall is inclined strongly forwards and inwards, with few exceptions. The anterior runs in with a tendency forward at its deeper part. The floor is always convex, dipping externally and internally. The general direction of the bony meatus seems to be in the majority of cases nearly horizontally inwards and forwards.



It now appeared desirable to map out on the surface of each preparation two important points—namely, the position of the lateral sinus, and the level of the roof of the tympanum and mastoid antrum (that is, of the upper surface of the petrous portion of the temporal bone at its outer part), in such a way that their relations to the mastoid region might be easily seen. The following method was adopted:—A fine drill was driven from within through the bone, at short intervals, along the course of the lateral sinus from its beginning to the point at which it bent inwards towards the jugular foramen, care being taken to hold the drill at right angles to the sagittal plane of the specimens, and to make the holes regularly, a fixed distance from the margins of the sinus. Externally these holes were quite distinct, and by their aid an exact representation of the lateral sinus was drawn clearly on the exterior of every specimen, so that a glance showed its relation to the meatus, &c. By the same method I found the level of the upper surface of the petrous portion of the temporal, not where it actually abuts against the vertical plate of the squamous, for here it slopes upwards, but some distance from this plate, where it forms the roof of the antrum mastoideum and inner part of the meatus (from which it is separated by cells). This I also marked distinctly on the exterior of the bone.

With regard to the level of the roof of the antrum, formed by the upper plate of the petrous, I found that this varied chiefly in two ways—first, in its height above the upper margin of the meatus; and, secondly, in the direction of the plate of bone itself. Generally this plate is horizontal, or nearly so.<sup>a</sup> It frequently is raised posteriorly, sloping backwards and upwards, or it may be arched or irregular (see figures).

The height from the meatus, just internal to its upper border, to the line of the roof of the antrum marked on the exterior of the skull, was—

$\frac{1}{16}$	of an inch in	2	per cent.
$\frac{2}{16}$	”	25	”
$\frac{3}{16}$	”	27	”
$\frac{4}{16}$	”	27	”
$\frac{5}{16}$	”	3	”
$\frac{6}{16}$	”	16	”

This shows a variation from  $\frac{1}{16}$  of an inch in 2 per cent. to  $\frac{3}{8}$  in 16 per cent., with an average slightly under  $\frac{1}{4}$  of an inch.

<sup>a</sup> This is at some distance from the squamosa.



It is important to bear in mind the variations here shown in all operations which seek to open the antrum without entering the cranial cavity, and, on the other hand, in operations intended to open both cranial cavity and mastoid cells at the same time, as in that of Mr. Wheeler. We have seen that the petrous may extend to a height of  $\frac{3}{8}$  of an inch above the meatus in a considerable proportion of skulls, but that it may be in others almost as low as the upper margin of the meatus. The usual height is about  $\frac{1}{4}$  of an inch, and as the plate of bone generally lies nearly horizontally, the level is almost the same immediately behind the meatus as directly above it. (As already explained, the height here given is that of the upper surface of the petrous some short distance from its junction with the squamous. At the junction of the two the petrous is often prolonged upwards in a sloping fashion for some distance, but this must be disregarded when considering the lines to be adopted as guides in perforating to a depth such as that at which the antrum lies.)

From the foregoing it will be seen that if, in *every* possible case, we wish to avoid the cranial cavity when drilling into the antrum the instrument should not be placed above the level of the extreme upper margin of the meatus, otherwise the cranial cavity will be occasionally opened (see Fig. 2 F).

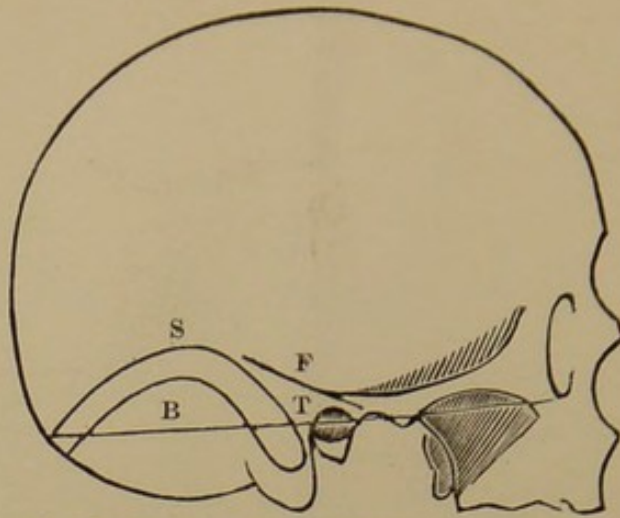
By the method previously described I examined the position and relations of the lateral sinus mapped on the exterior of the skull in a hundred specimens with, I think, pretty definite results. It will be best to quote the accounts given of the surface marking for this sinus in some of our best known text-books, and then point out in what my results agree with or differ from these.

Few text-books give a careful account of the direction and topography of the sinus. In Quain (volume I., page 668) we find: "From the latter point (*i.e.*, external occipital protuberance) the lateral sinus runs horizontally outwards and forwards to a spot about an inch behind the external auditory meatus, where it turns downward towards the mastoid process." Treeves and Owen give a similar description. Professor Windle, in his work on "Surface Anatomy," says that a line from the external occipital protuberance to the point of the posterior inferior angle of the parietal bone—the asterion—will mark the position of a part of the lateral sinus. "At the asterion," he says, "it turns down and runs behind the posterior border of the mastoid process to the base of the skull."



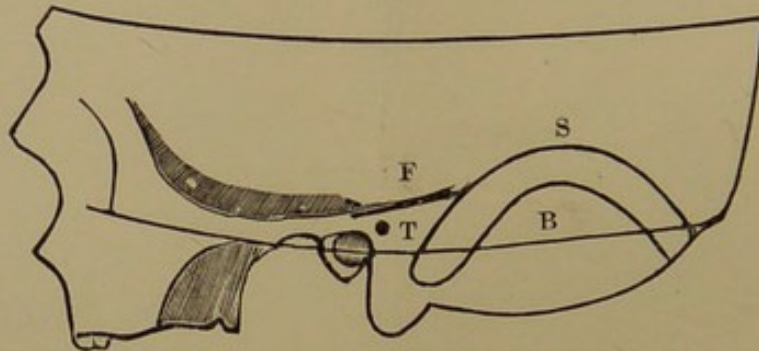


Fig. 1.



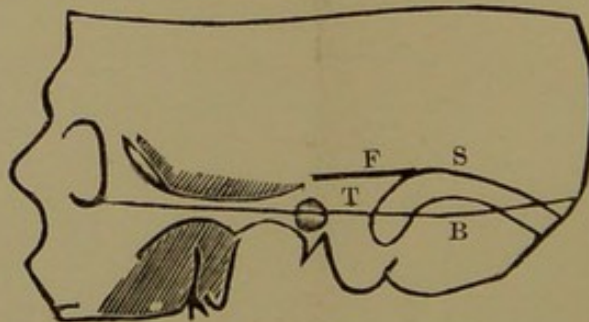
S, lateral sinus ; B, Reid's base line ; F, level of floor of middle fossa of skull ; T, triangle in which drill-hole may be made. It is small in this case ; the sinus arches up very high, and comes far forward. Observe marked curve of sinus and its relation to base line. (From a photo.)

Fig. 2.



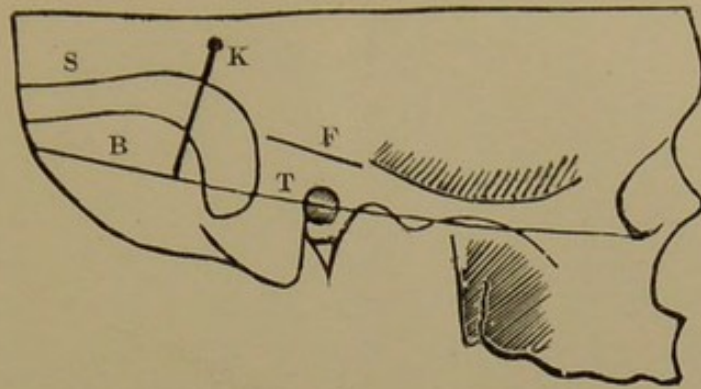
S, lateral sinus ; B, Reid's base line ; F, floor of middle fossa ; T, triangle for drill-hole. The triangle is large in this case ; lateral sinus considerable distance from meatus ; F is rather low. Observe relation of sinus to base line. The round mark in front of T is the point corresponding to the antrum. (From a photo.)

Fig. 3.



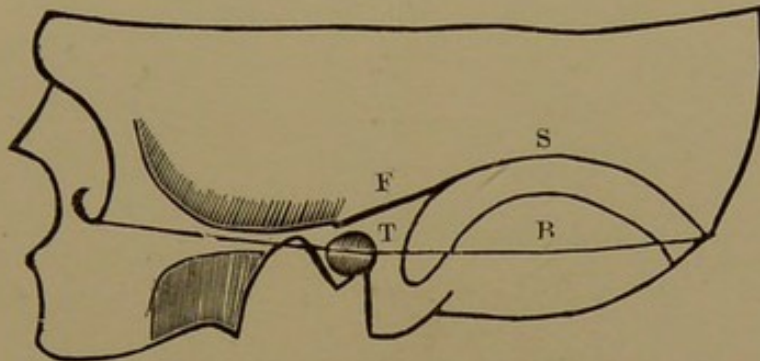
S, lateral sinus ; B, Reid's base line ; F, floor of middle fossa ; T, triangle for drill-hole ; triangle large. This is the only case in which the lateral sinus lies near the base line. (From a photo.)

Fig. 4.



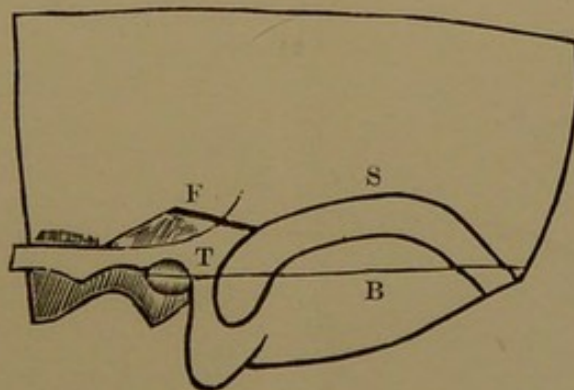
S, lateral sinus ; B, Reid's base line ; F, floor of middle fossa ; T, triangle for drill-hole ; K, site proposed by Mr. Baker for trephining in temporo-sphenoidal abscess. Observe the proximity of the lateral sinus in this case to the site. Here the lateral sinus lies high above base line posteriorly, and it is enlarged where it bends down on the mastoid. (From a photo.)

Fig. 5.



S, sinus ; B, base line ; F, floor of middle fossa ; T, triangle for drill-hole. Here the sinus is rather near the meatus, and F is low. (From a photo.)

Fig. 6.



S, sinus ; B, base line ; F, floor of middle fossa ; T, triangle for drill-hole. In this case the sinus presents abrupt bends instead of gentle curves, and it approaches near to the base line and near to the meatus. (From a photo.)





These are the best descriptions of the topography of the sinus which I have met with. Before criticising them I wish to point out that the relations of the lateral sinus to the surface are extremely inconstant, so much so that it is impossible to lay down any method of arriving at the position of the sinus accurately in every case. These irregularities are due, to a certain extent, to varieties in the curves of the sinus, but to some extent also to irregularities in the bones.

Regarding the description in Quain quoted above, it is correct to say that the sinus, as a rule, corresponds posteriorly to the level of the occipital protuberance. (I have found it lie at this level in 50 per cent. of the cases examined, below it—but never more than  $\frac{1}{2}$  an inch—in 33 per cent., and above it in the remaining 17 per cent.) Beyond this the description in Quain, adopted by Treeves and Owen, differs completely from what I have found. I would say the sinus never runs *horizontally* forwards and outwards from the occipital protuberance. On the contrary, it forms a distinct and well-marked arch, with a varying height. The anterior extremity of this arch corresponds to the point where the sinus turns in to the base of the skull—a point about  $\frac{1}{4}$  or  $\frac{1}{8}$  of an inch below the level of the floor of the meatus and a variable distance behind it; the posterior end is at a point somewhere near the occipital protuberance. Usually the posterior end of the arch is on a higher level than the anterior by about half an inch. From the occipital protuberance—which, it will be remembered, in most cases lies above the base line—the sinus arches gradually upwards, sometimes more quickly, sometimes more gently, until it reaches its greatest height at a point found, on an average,  $1\frac{1}{2}$  inches behind and nearly  $\frac{3}{4}$  of an inch (measuring to the upper margin of the sinus) above the centre of the external auditory meatus. Here it turns down gradually or abruptly, and runs just in front of the posterior margin of the mastoid process and a line prolonging that margin upwards and backwards; finally it turns in towards the base of the skull below the level of the meatus (Figs. 1 and 2 S).

As regards the bend of the sinus where it turns down at the asterion, it may vary within wide limits. It may be merely a gentle curve, so gentle that it is hard to say where the dip down really commences (Fig. 5); on the other hand, it may be very sharp, presenting a distinct apex or knuckle (Figs. 3, 4, 6), or it may be anything between these two conditions. Further, the height of this bend above the base line is very variable; in some



cases it is only  $\frac{3}{16}$  of an inch, in others it reaches  $\frac{1}{2}$  of an inch, measuring to the middle line of the sinus—which means that the upper margin of the sinus is sometimes found more than an inch above the base line, although this part of the base line is considered to correspond to the transverse fissure of the brain, that is, generally to the lateral sinus. As a rule, the sharper the bend of the sinus the greater is its height. The average height above the base line is nearly  $\frac{3}{4}$  of an inch, measuring to the upper margin of the sinus at the bend. These measurements are of importance in trephining for temporo-sphenoidal abscess according to the lines laid down by Mr. Barker.<sup>a</sup>

From the bend the sinus runs downwards and forwards on the inner surface of the mastoid at an angle of about  $60^\circ$ ; and in the opposite direction it runs downwards and backwards on the occipital in a gentle slope.

Now to localise these parts of the sinus on the surface. The lower and anterior end—the point where the sinus turns in to the base of the skull—will be found from  $\frac{1}{4}$  to  $\frac{1}{6}$  of an inch below the level of the lower margin of the meatus and somewhere in front of the posterior margin of the mastoid. The apex of the curve, as just pointed out, usually lies  $1\frac{1}{2}$  inches behind and slightly less than  $\frac{3}{4}$  of an inch above the level of the centre of the meatus.<sup>b</sup> The posterior end lies at or immediately below the level of the external occipital protuberance, but it would be unwise to consider that it will be invariably found at this level. It should be given a full  $\frac{1}{2}$  inch below and as much above the point of the protuberance as its field of wandering. It ought to be also pointed out that very frequently the sinus turns up into the superior longitudinal or straight sinus before it reaches the protuberance.

To localise the portion of the sinus behind the apex of the curve, probably the simplest line is that given by Professor Windle; a line from the protuberance to the asterion usually corresponds pretty well to this part of the sinus, but it is occasionally too low. If the asterion cannot be made out in the living subject, then we must fall back on its relation to the curved lines of the occipital and the base line of Reid.

The superior curved line is a fair guide to the sinus *at its*

<sup>a</sup> Manual of Operative Surgery; and elsewhere.

<sup>b</sup> Although this is the position of the "apex" when marked, in those cases which have only a gentle curve the sinus may reach to about the same height for an inch further back.



*posterior part.* I have seen it  $\frac{1}{2}$  of an inch above the curved line, and, on the other side,  $\frac{1}{2}$  an inch below. Nevertheless, in the majority of cases, the sinus may with safety be sought for at or immediately below the superior curved line, within an inch of the occipital protuberance. (At the curved line, 65 per cent.; below, 27 per cent.; above, 8 per cent.)

The relation of this posterior part of the sinus to the base line is most variable. In 57 per cent. it lies entirely above the base line, in 29 per cent. at the base line posteriorly and then arches upwards and forwards to the apex, and in 14 per cent. it lies below the line posteriorly—that is, in 57 per cent. of skulls the sinus, from its posterior end to the part lying behind the meatus, is placed bodily above the base line; in another 29 per cent. it is at the same level behind, but above it in the rest of its course to the meatus. Treeves gives the following direction for mapping out the sinus, in his “Surgical Anatomy”—a book of which I cannot speak too highly:—“The lateral sinus whose course is represented by a line drawn horizontally from the occipital protuberance to a point about 1 inch behind the external meatus of the ear, where it turns downwards, to groove the mastoid process.” Owen, in his late manual, gives similar directions. A glance at my diagrams will show at once that such a line, in the majority of cases, gives no idea of the true position of the sinus. I have pointed out above that its upper margin will in some cases be found over an inch, and, in the average condition, nearly  $\frac{3}{4}$  of an inch from this line at a point where it is of the utmost importance that it should be properly localised—namely, near the seat of trephining for temporo-sphenoidal abscess.

Though I was happily able to agree with Professor Windle in his method of localising the portion of the sinus just treated of, I fear I must differ from his description of that part of it which lies in front of the bend. He says:—“At the asterion it turns down and runs behind the posterior border of the mastoid process to the base of the skull”—and his is the only attempt in any of the books mentioned to locate this part of the sinus. The examination of my specimens leads me to a different conclusion. I have never seen the sinus, as a whole, run down behind the posterior margin of the mastoid process; in the average condition it runs just in front of this margin, and a line running upwards and backwards from it, but as a rule they are not parallel, for the sinus is somewhat nearer to the vertical than the border. This is



the average condition, but I have seen the *posterior margin* of the sinus as much as  $\frac{1}{4}$  of an inch in front of the border, and, on the other hand, I have seen occasionally its posterior margin lie very slightly behind the border of the process, but, even in these cases, the sinus as a whole lay decidedly in front of the border of the mastoid. With a broad mastoid process the sinus will be more likely to lie some distance in front of the border than with a narrow one; still, even with a very wide process, the sinus may extend quite back to its posterior edge. In connection with this, it may be remarked that the groove for the sinus occasionally becomes much broader here where it lies on the mastoid than it is in the rest of its extent.

From the foregoing it is seen that the relation of the sinus to the posterior margin of the mastoid is variable; its relation to the posterior wall of the external auditory meatus is even more variable, and this relationship is a matter of vital interest in opening the mastoid cells. I have found the anterior margin of the sinus reach to within  $\frac{3}{16}$ , that is very little over  $\frac{1}{8}$ th, of an inch of the posterior wall of the meatus; on the other hand, in 3 cases, the distance was  $\frac{1}{2}$ , or  $\frac{3}{4}$  of an inch; the average distance being  $\frac{1}{2}$  an inch. This matter and the distance of the sinus from the surface will be more fully treated of further on.

Summarising these facts relating to the position of the lateral sinus, it may be described as beginning at or near the occipital protuberance; from this it runs for a distance along the superior curved line, gradually ascending from this and the base line until its upper margin reaches a height of nearly  $\frac{3}{4}$  of an inch from the base line at a point an inch and a half behind the centre of the meatus; here it turns down and forwards running on the mastoid just in front of its posterior border, about half an inch behind the posterior wall of the meatus;  $\frac{1}{4}$  inch below the meatus it turns in to the base of the skull.

Having thus mapped out the position of the lateral sinus it would be well to see what relation the seats recommended for trephining in temporo-sphenoidal and cerebellar abscess bear to it. I shall consider the operations proposed by Mr. Barker. He, in trephining for temporo-sphenoidal abscess, directs the pin of the trephine to be placed  $1\frac{1}{4}$  inches above and  $1\frac{1}{4}$  inches behind the centre of the meatus.<sup>a</sup>

An examination of my specimens shows that if the pin of a  $\frac{3}{4}$ -

<sup>a</sup> Manual of Surgical Operations, p. 402.



inch trephine (outside measurement) be placed at the point indicated by Mr. Barker, the lateral sinus will be exposed or at the edge of the opening in about 15 per cent. of cases. I have measured the distance from the base line to the upper border of the sinus, *at a point  $1\frac{1}{4}$  inches behind the centre of the meatus*, the maximum was  $\frac{1}{16}$  inch, the minimum  $\frac{5}{16}$ , the average  $\frac{5}{8}$  inch.

A large posterior branch of the middle meningeal artery is almost always exposed in a trephine hole made, according to Mr. Barker's rules, with a  $\frac{3}{4}$ -inch trephine, but it will be exposed probably just as often by an aperture  $\frac{1}{2}$  an inch higher up.

Further, according to the diagram in his book, Mr. Barker's operation exposes the middle temporo-sphenoidal convolution; this, I fear, will not be the case in the majority of heads; the inferior temporo-sphenoidal corresponds, I would say, more closely to the hole.

With the object of avoiding the lateral sinus in all cases, I would suggest, in trephining for temporo-sphenoidal abscess, that the centre of the trephine should be placed  $\frac{1}{2}$  an inch above the point suggested by Mr. Barker—that is, the pin of the trephine should be  $1\frac{1}{4}$  inches behind and  $1\frac{3}{4}$  or even 2 inches above the centre of the external auditory meatus.

For opening cerebellar abscess, Mr. Barker directs the trephine to be placed  $1\frac{1}{2}$  inches behind the centre of the meatus and 1 inch below the base line. Such a site is, I believe, perfectly safe so far as the lateral sinus is concerned; but, as mapped out on the dry skull, in some heads it falls very near the mastoid process, and would, undoubtedly, occasionally engage the trunk of the occipital artery as it lies in the groove of the temporal; besides, the bone is here a considerable distance from the surface. On the other hand, Mr. Barker states that, at this point, the most accessible part of the abscess, if present, will be reached. As to this I can give no opinion, but, if shifting the position of the trephine half an inch backwards would entail no inconvenience from the surgical point of view, apparently from the anatomical view a more suitable site would be two inches behind the middle of the meatus and an inch below the base line; here the lateral sinus is out of danger, the bone is not far from the surface, and the occipital artery may be avoided.

The surface marking for the transverse fissure separating the cerebrum from the cerebellum, will be the line of the lateral sinus as far as the asterion, and, as shown above, this agrees in no way



with the part of Reid's base line behind the meatus, which is usually given in text-books of anatomy and surgery as the marking for the sinus and the fissure.

Since it has become a well-recognised operation to trephine the lateral sinus for septic thrombosis, I have sought for some point at which the anterior part of the sinus might be reached with certainty. If the asterion be adopted, a trephine here will always reach the sinus, but then the asterion is not easily made out in the living subject, it is too far away from the ear, the seat of the primary disease, and, besides, it is a variable point sometimes at the base line, sometimes as much as  $\frac{5}{8}$  of an inch above it (its distance behind the middle of meatus varies from about  $1\frac{1}{2}$  to 2 inches). In its varying positions it seems to drag the lateral sinus constantly with it.

The best site I can suggest is at a point  $1\frac{1}{8}$  inches behind the centre of the meatus, and on the level of a line drawn horizontally backwards through the extreme upper margin of the bony external auditory meatus; this will be about  $\frac{1}{4}$  of an inch above the base line. In every case a hole made with the pin of a  $\frac{3}{4}$ -inch trephine at this point will expose the lateral sinus. In some few cases the sinus will not be fully shown by this opening, but in the large majority it will be thoroughly exposed. A little difficulty in such an operation may arise from the fact that the trephine hole will overlies the upper and posterior angle of the petrous portion of the temporal, which is here prolonged backwards as a projecting ridge. In removing the crown of bone this will offer some opposition.

From what I have seen of the variations of the sinus, and from what I have tried to set forth above regarding it, my advice to those who wish to trephine the skull in this region and to avoid *all* risk of wounding the sinus would be—if you are to trephine above the sinus, draw a line convex upwards from a point  $\frac{1}{2}$  an inch above the external occipital protuberance to a point  $1\frac{1}{2}$  inches behind the centre of the meatus and  $1\frac{1}{4}$  inches above it. You may with safety bore the skull above this. If, on the other hand, you wish to trephine below the sinus draw a line from a point  $\frac{1}{2}$  an inch below the occipital protuberance to the level of the base line  $1\frac{1}{2}$  inches behind the meatus. You may bore below this without endangering the sinus; these lines mark out the extremes between which it varies.

I next turned my attention to the localisation of the mastoid



antrum and to some of its relations. All my observations up to the present have been made on adult skulls, consequently I have no remarks to make upon the development of the region and the changes associated with age. For information on these points I would refer to Dr. Symington's masterly work on the anatomy of the child, and elsewhere. Regarding the anatomy of the parts in the interior of the bones I have little to add to the descriptions found in works on the ear, such as Dr. Buck's. From these we learn that behind and external to the tympanum lies the common sinus of the mastoid cells or antrum mastoideum, communicating with the cavity of the tympanum by a triangular aperture, with sides of about  $\frac{1}{8}$  of an inch; that this antrum is usually large enough to contain a small pea, that it is always present, even in the infant, and that into it open the mastoid pneumatic cells, which are found everywhere on its walls except on the roof. These pneumatic cells, Buck tells us, extend, when fully developed, up to within  $\frac{1}{2}$  an inch of the temporo-parietal suture. Anteriorly they extend forwards over the auditory meatus; but posteriorly they end abruptly in the neighbourhood of the temporo-occipital suture, extending in some very rare cases even past the suture into the occipital bone. Buck also says: "The lateral sinus occupies a groove on the bone in the immediate vicinity of the posterior limits of the mastoid cells;" and he points out the short distance—3 to 6 mm.—from the sinus to the posterior wall of the antrum.

Symington and Buck quote the result of an examination of 250 adult temporals made by Zuckerkandl, which shows that in 20 per cent. there were no air cells save the antrum, the bones being entirely solid or diploic; in 36·8 per cent. the cells of the mastoid were entirely pneumatic; and in 43·2 per cent. they were partly pneumatic, partly diploic.

In connection with these generally adopted views I would remark that I have found the opening between antrum and tympanum to agree closely with the description given above. Regarding the constancy of the antrum, I have found it completely absent in one case—a solid mastoid; in another solid mastoid there was a fair-sized antrum normally connected, and behind it, but separated from it completely by a plate of bone, another similar but isolated cavity. Contrary to what Buck states, I have occasionally found small pneumatic cells in the roof of the antrum, and opening into it. Further, the lateral sinus does not always lie in a groove along



the back of the mastoid cells; this, certainly, is the most common arrangement, but frequently the cells extend for a considerable distance behind the sinus, so that it is imbedded in a groove on the inner aspect of the cells. This is important, for to reach the sinus from the outside in these cases the cells should be first perforated. Regarding the absence of pneumatic cells, I was rather surprised at the frequency of solid mastoids; I have found even a larger percentage of them than Zuckerkandl, but he examined a much greater number of skulls.

As the radical operation for the treatment of mastoid disease is draining of the antrum by perforating from the exterior, I tried to find a point on the surface corresponding to the antrum internally. After examining my specimens I came to the conclusion that such a point would lie *immediately* behind the posterior margin of the bony meatus, and *immediately* beneath a line prolonging horizontally backwards its upper margin (Fig. 2). At this point I sent a fine drill (diameter  $\frac{1}{10}$  inch) straight in—horizontally and transversely; and out of a hundred specimens, in every one which had an antrum—that is, in ninety-nine—the drill entered that cavity, or, in a small minority of cases, the cells immediately below and behind the antrum. In the majority of cases, as just said, the antrum was opened; but even in those comparatively few in which the cavity itself was not reached the opening of the cells situated on the walls of the antrum was all but as satisfactory; for these cells communicate freely with it, and besides, in disease of the antrum, its cavity is much enlarged, and the adjacent cells, owing to absorption of the bony trabecular, are thrown into it. I was satisfied that this point marked on the surface the position of the antrum sufficiently well; still, in the majority of cases, it might be more fully entered by shifting the drill point  $\frac{1}{12}$  of an inch upwards; in some few rare specimens an aperture at such a point would open into the cranial cavity, owing to the occasional low level of the roof of the antrum (as shown in a previous table). Consequently I adopted the former point for safety sake, and I believe it to be thoroughly effective.

I next measured in these specimens the distance of the inner wall of the antrum—that is, the outer wall of the posterior part of the labyrinth, from the exterior of the bone, measuring through the drill hole. To do this the more effectively I removed the roof of the antrum. The following was the result of the measurements:—



Distance from inner wall of antrum to exterior of bone—

$\frac{9}{16}$  inch in 2 specimens.

$\frac{5}{8}$	„	19	„
$\frac{11}{16}$	„	36	„
$\frac{3}{4}$	„	34	„
$\frac{13}{16}$	„	4	„
$\frac{7}{8}$	„	4	„

This gives an average of a little under  $\frac{3}{4}$  of an inch, with a minimum a trifle under  $\frac{5}{8}$  and a maximum of  $\frac{7}{8}$  of an inch.

This distance was sought in order to decide how far the drill or other instrument should be sent in when boring for the antrum; for if the perforation go too far the labyrinth may be injured. Buck says the antrum should be reached at a depth of  $\frac{3}{4}$  of an inch. With this my observations agree completely. I calculated that the distance would be  $\frac{5}{8}$  of an inch—that is, only  $\frac{1}{40}$  of an inch more than Buck's measurement. He further says his rule is never to force the instrument beyond  $\frac{3}{4}$  of an inch, although Schwartze places the extreme limit at 1 inch (25 mm.). I believe the distance laid down by Buck to be the more judicious—namely,  $\frac{3}{4}$  of an inch. I have no doubt that an instrument sent in for an inch would, in a considerable number of cases, cause injury to the labyrinth.<sup>a</sup>

My plan in drilling the specimens was this:—I placed a mark on the drill  $\frac{3}{4}$  of an inch from its point, and I always found that I had bored far enough by the time that the mark on the drill reached the surface of the bone. The sensations felt on boring were—first, the decided hard resistance due to the outer table; next, an irregular gritty resistance caused by the diploe; then the drill ran freely into a cavity and was stopped suddenly by contact with the inner wall of the antrum. I feel sure that there can be very little difficulty in finding the antrum in a case of mastoid disease where its cavity is much enlarged, if the hole be made at the point on the surface mentioned above.

<sup>a</sup> Since I communicated this paper to the British Medical Association in July, 1890, I have read a paper by Dr. Arthur Hartmann, communicated to the International Medical Congress at Berlin in the following August. He examined fifty specimens, chiefly with the object of finding the distance of the facial canal and the external semicircular canal from the surface behind the ear. His results were briefly as follows:—Out of 50 specimens he found the facial canal under  $\frac{3}{4}$  of an inch from the surface six times (the distances were, in two 17·5 mm., in four 18 mm.,  $\frac{3}{4}$  of an inch being a little under 19 mm.). In the same specimens he found the external semicircular canal less than  $\frac{3}{4}$  of an inch from the surface in 5 cases (viz., once 17 mm., twice 17·5, and twice 18 mm.).



I would refer incidentally to the inaccurate descriptions given of the position of parts represented on the upper surface of the petrous portion of the temporal bone, even in some of the latest and best text-books of anatomy. The eminence corresponding to the superior semicircular canal is taken as a landmark; then it is usually said there will be found a depression external to it corresponding to the roof of the tympanum, and that the antrum lies posterior and external to this. This is not accurate—the depression corresponding to the tympanum will be found in front of, not outside, the eminence of the superior semicircular canal; the roof of the tympanum, which is oblong, crosses the line of the canal in front like the top of the letter T, with this difference, that it does not cross it at right angles, but rather obliquely, making a smaller angle externally than internally; while the depression external to the semicircular canal corresponds not to the tympanum, as usually stated, but to the antrum; further, this depression is frequently replaced by a well-marked eminence produced by the development of pneumatic cells in the roof of the antrum, or it may be much depressed, particularly in cases of absence of pneumatic cells and solid mastoids.

Having satisfied myself that the point mentioned above, immediately behind the meatus, and immediately below the level of its extreme upper border, marked upon the surface the position of the antrum sufficiently well for all practical purposes, and having found the distance of the antrum from the surface, I next sought for a method of passing a useful-sized instrument into the antrum, guided by this point and the information previously obtained. I may say at once that *in the majority of cases* a  $\frac{1}{3}$ -inch or even a  $\frac{1}{2}$ -inch instrument could probably be passed into the antrum and mastoid cells if the margins of the hole made lay immediately behind the meatus, and extended up to the level of its extreme upper border. But then, on the other hand, there was a certain number in which such an opening would lead into the lateral sinus. Unfortunately I could not distinguish from an examination of the exterior which was a dangerous and which a safe case for such an operation; consequently I turned my attention to finding some method of reaching the antrum with a fair-sized instrument, even in the worst and most dangerous cases, without injury to the sinus, and without entering the cranium.

The point which I have spoken of as marking on the surface the position of the antrum lies within a triangle (Figs. T.), bounded by



two variable and one fixed side. The latter is the posterior border of the meatus, the remaining sides of the triangle are an upper corresponding to the level of the roof of the antrum—that is, the upper surface of the petrous portion of the temporal—and a posterior side formed by the lateral sinus. In this triangle the instrument must be sent in.

The first side, formed by the back of the meatus, is constant, or nearly so, but it may be mentioned that this posterior wall of the meatus occasionally, though rarely, runs nearly straight in, instead of sloping forwards. The upper boundary corresponding to the roof of the antrum is very variable. Its height, measured from the upper wall of the meatus just internal to its orifice, has been given already in tabular form. On reference to that table it will be seen that the distance usually varies from  $\frac{1}{8}$  to  $\frac{1}{4}$  of an inch with an average of over  $\frac{3}{16}$ , but in 2 per cent. of skulls it falls to  $\frac{1}{16}$  of an inch. Putting this in other words, in almost every case a trephine hole may be made as high as a point  $\frac{1}{12}$  of an inch above the upper margin of the meatus without danger of opening into the cranium; but in a certain small proportion of cases such a hole would open the cranial cavity, and in order to secure safety in all cases the aperture should extend only up to the level of the extreme upper margin of the meatus, and should never reach higher than this.

It ought to be pointed out here that if only a shallow opening is being made not exceeding a depth of  $\frac{1}{3}$  of an inch, or thereabout, it may be at a higher level than that just suggested; for, owing to the sloping upwards of the superior surface of the petrosa where it abuts against the squamous portion of the bone, there will be no danger of entering the cranium, unless the aperture be of some depth.

The most important of the boundaries of the triangle, and, I believe, the boundary at which there is the greatest danger, is the posterior, formed by the lateral sinus. It has been pointed out that the position of the sinus is most variable; it is sometimes near the meatus, sometimes far off, sometimes it lies near the surface of the bone, again it runs deeply. A closer examination of its relations and varieties will be useful.

We have already seen that the lateral sinus, after arching upwards and forwards from the region of the occipital protuberance, turns downwards and forwards at a point about  $1\frac{1}{2}$  inches behind, and nearly  $\frac{3}{4}$  of an inch above, the centre of the auditory meatus



(measuring from the upper margin of the sinus). At this point, as previously shown, it may bend gradually or sharply, then it runs downwards and slightly forwards in front of the posterior margin of the mastoid—not quite parallel to it, but rather more vertically—and finally turns into the base of the skull about  $\frac{1}{4}$  of an inch below the level of the floor of the meatus. Its relation to the posterior margin of the mastoid I have already referred to, and I have pointed out how much this part of the sinus varied in its position. Its varieties in two special directions are of particular importance just now—namely, in its relations to the posterior wall of the meatus, and in its distance from the external surface of the bone. Regarding the former I must point out that, owing to the direction of the sinus forwards as well as downwards, and the curved form of the posterior wall of the meatus, the distance between the two will be greater above than at the level of the centre of the meatus. Consequently I have selected the latter level, and measured in a hundred specimens along the base line, that is, opposite the centre of the meatus, the distance of the anterior margin of the sinus from the posterior wall of the meatus—

It measures  $\frac{3}{16}$  of an inch in 1 case.

„	$\frac{4}{16}$	„	1 „
„	$\frac{5}{16}$	„	4 cases.
„	$\frac{6}{16}$	„	20 „
„	$\frac{7}{16}$	„	17 „
„	$\frac{8}{16}$	„	17 „
„	$\frac{9}{16}$	„	15 „
„	$\frac{10}{16}$	„	18 „
„	$\frac{11}{16}$	„	4 „
„	$\frac{12}{16}$	„	3 „

X This gives an average of about half an inch as the distance of the sinus from the back of the meatus, measured on the base line. But here in particular averages are of little practical value. What we must seek is the most anterior point at which the sinus may be found. On looking at the table it will be seen that in one case it was  $\frac{3}{16}$  of an inch, in one  $\frac{1}{4}$  of an inch, and in four  $\frac{5}{16}$  of an inch from the meatus. We may put these together for practical purposes, and say that in 6 per cent. of cases the sinus will be little more than  $\frac{1}{4}$  of an inch from the back of the meatus. Two of these 6 in my specimens were solid mastoids. In the majority of the specimens the distance between the sinus and the



meatus ranged from  $\frac{3}{8}$  to  $\frac{3}{4}$  of an inch. If we are to regard the rights of such a small minority as 6 in 100, we must seek some means of avoiding the sinus in these dangerous cases. In considering how to do this in the 6 specimens referred to, it must be remembered that the distance of the sinus from the meatus given is that measured at the base line, and consequently the shortest. As the sinus slopes upwards and backwards, and the meatus upwards and forwards, the distance between the two is greater the higher up we go; but in seeking this wider interval the line of the roof of the antrum must not be encroached upon if we are to avoid opening into the cranium. The line of safety in this direction has been already laid down; unfortunately this line is not at as high a level as would permit of the selection of a site corresponding to the widest interval between the sinus and meatus. In the 6 cases under consideration the triangle within which the boring should be made was reduced to a very small area, still in each of them a  $\frac{1}{4}$  inch drill might, if properly placed, be sent in without injuring the sinus, and without encroaching on the line of the roof; in one of them certainly only with the greatest care—namely, that in which the sinus was  $\frac{3}{16}$  of an inch from the meatus. In the two worst of these cases the use of a larger instrument could not be thought of; it would undoubtedly injure the sinus. In the other four, *possibly*, a  $\frac{1}{3}$  inch drill might be used.

A consideration of these facts led me to the conclusion that, if we are to adopt some means of avoiding the sinus in these bad cases—which are about 6 per cent. of all examined—we must use a  $\frac{1}{4}$  (or possibly  $\frac{1}{3}$ ) inch drill, or other boring instrument; and secondly, we must select a particular site which will be within the triangle of safety referred to above. This second point will be accomplished if we place the drill so that the aperture it makes shall be *as near as possible* to the posterior border of the meatus, and its upper margin *quite as high as the extreme upper margin of the meatus*. In those cases in which the upper border of the meatus is ill-defined, and slopes gradually inwards, the point at which it first markedly begins to slope in should be taken as representing its upper margin. If the operator is willing to run the risk of opening into the cranial cavity in 2 per cent. of cases, he may, with greater safety to the lateral sinus, allow the upper margin of the drill-hole to reach to a height of one-twelfth of an inch above the border of the meatus. Even if the cranium be



opened into slightly, I imagine few evil results would follow; the fact that the cavity was entered would soon be discovered, and care might be taken to go no further in that direction. If this danger of opening the cranial cavity in 2 per cent. of cases be not of sufficient gravity to give trouble, I would strongly recommend the adoption of the latter level—namely, that in which the upper margin of the drill-hole is at a level of one-twelfth of an inch above the border of the meatus.

So much for the point on the surface at which the drill should be applied; now as to the direction in which it ought to be driven in. I believe it will be most judicious to pass it straight in—horizontally and transversely—neither forwards or backwards, upwards or downwards. Certainly if it be directed a little forwards there will be less danger of wounding the sinus, still there is danger of wounding the facial nerve, which runs down along the inner margin of the opening from the tympanum into the antrum, if the drill be directed much forwards; and the aperture may be made in safety without resorting to this means of avoiding the sinus.

Summing up, then, it is my experience that a  $\frac{1}{4}$ -inch trephine or drill may be passed directly in at the spot indicated above without any great danger. Such an opening will drain the antrum, and if it be considered of insufficient size it may be carefully enlarged at its superficial part—for near the surface the aperture may be made very large without danger—and this enlargement continued inwards if no difficulty be experienced. If a larger drill be selected there will be undoubtedly danger in a certain small number of cases. But under all circumstances the anterior and upper borders of the opening made ought to be at the lines indicated above.

I must here deprecate strongly, from an anatomical point of view, the site given by some authors for opening the antrum—namely, a quarter (or by others a half) inch behind the meatus, and below the level of its upper border.

I have referred incidentally to the facial nerve, and I have pointed out that it will not be in danger when the drill is sent straight in at the spot selected; it will lie in front of such an aperture. But if, on the contrary, the instrument be directed forwards, the nerve will be endangered if the drill be passed far in.

Another important relation alluded to previously is the distance of the lateral sinus from the exterior of the bone. This is evidently a matter to be considered in connection with opening of the mastoid cells behind the meatus.



I have measured the distance of the sinus from the surface in 90 cases with these results:—It was  $\frac{1}{12}$ th of an inch in 1 case,  $\frac{1}{8}$ th of an inch in 2,  $\frac{3}{16}$ th in 9, a  $\frac{1}{4}$  inch in 21, and in the remaining cases it varied from  $\frac{1}{4}$  up to  $\frac{10}{16}$ th of an inch; the average was about  $\frac{5}{16}$ th.

The cases in which the sinus was very near the surface were those in which it lay entirely behind the mastoid cells, so that it was separated from the surface simply by the diploic and outer and inner tables of the skull, or sometimes merely by a layer of compact bone.

These figures show how dangerous indiscriminate trephining behind the ear may be; in one case a hole only  $\frac{1}{12}$ th of an inch in depth would expose the lateral sinus, a hole  $\frac{1}{8}$ th of an inch would accomplish this in 2 others, and it required only a hole  $\frac{3}{16}$ th of an inch in depth to expose it in other 9. I think the practical inference from a consideration of these facts is that all apertures behind the meatus should be made with the greatest care, for we know not how near the lateral sinus is.

What instrument should be used is a question upon which I can hardly offer a suggestion, but I know it ought to be an instrument the progress of which can be seen and kept under control. Further, the sinus should be expected at every movement, and no bold cutting should be done; then if the sinus be exposed, with such precautions, no harm in all probability will result from the mere exposure.

After this long digression I return to the starting-point of my communication, namely, the anatomy of Mr. Wheeler's operation. In his paper on "Trephining in Mastoid and Tympanic Disease,"<sup>a</sup> p. 9, he says, "The site I would select for operation, . . . would be such as to place the lower border of the trephine on a level with the external auditory meatus, and anterior to a line dividing vertically the mastoid process. By adopting this course there will be no danger of wounding the lateral sinus, the tympanum and mastoid cells will be opened, giving full exit for discharge, the dura mater will be exposed, and should pus exist between it and the cranium, there will be ample freedom for its escape."

What exactly Mr. Wheeler wished to convey in the foregoing it is not easy to say. The lower border of the trephine is to be placed on a level with the external auditory meatus; we are not told what part of the meatus—upper or lower border, or centre.

<sup>a</sup> Fannin & Co., Dublin.



Again, the trephine is to be placed in front of a line dividing vertically the mastoid process; such a line may be near to, or far from, the meatus, for the process may be divided vertically at any part of its surface. But reading Mr. Wheeler's words in the most favourable way, I presume he wished to convey that the lower margin of the trephine crown should be placed at the level of the upper border of the meatus, and the crown itself in front of a vertical line running through the most prominent inferior point or tip of the mastoid process (or possibly a vertical line dividing the process as a whole into two equal parts). If a trephine hole be made according to these directions, *as a rule* the lower part of the opening will correspond to the base of the petrous portion of the temporal bone here applied to the squamous, and the upper part, to the dura mater of the middle fossa of the skull. As Mr. Wheeler says there will be no danger of wounding the lateral sinus, the dura mater and mastoid cells will be exposed, but the tympanum (or antrum) could not possibly be laid open by such a trephine-hole alone, without great injury to the brain, for the tympanum is three-quarters of an inch from the surface, and if the lower part of the trephine were sent in to open this cavity, the upper part would burrow for a corresponding distance into the cerebrum. If, on the other hand, the crown of bone be removed when the upper part of the trephine has pierced the thin squamous plate some distance above the meatus, there will be exposed in the lower part of the opening, not the antrum or tympanic cavity, but simply the superficial mastoid cells—at least this would be the case in the normal mastoid, possibly in a case of disease the interior might be so much eroded that the antrum reached practically to the surface.

In a normal case, after removing the crown of bone, to reach the antrum it would be necessary to drill a hole straight in at the lower and back part of the trephine opening. Occasionally, owing to the low level of the superior surface of the petrous, as shown previously, a trephine sent in according to these directions would expose little more than the dura mater, with possibly just a very thin area of the petrous along the lower edge of the hole.

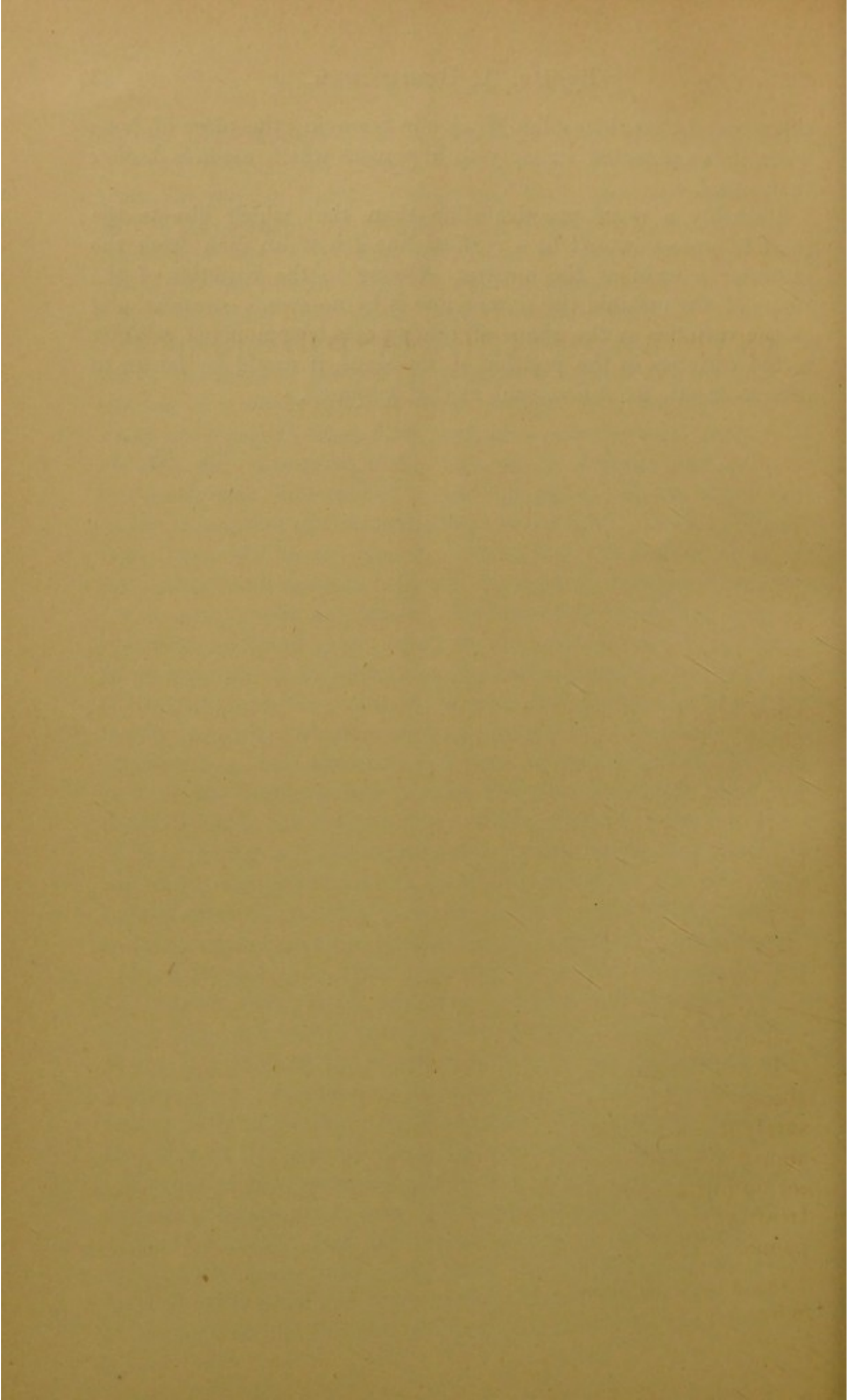
Certainly the operation gives free scope for relieving intracranial pressure from pus, the temporo-sphenoidal lobe may be explored directly, and the cerebellum by a curved needle, &c., through the tentorium. But there are two objections to it—the mastoid cells, when the upper surface of petrous lies low, may not be exposed at all, or only in a very slight degree; and secondly,



there may be considerable difficulty in removing the piece of bone when it is connected strongly to a petrous which ascends higher than usual.

Probably a more practical line than that which bisects the mastoid process would be a vertical line  $\frac{3}{8}$ th of an inch from the posterior margin of the meatus. Owing to the varieties of the shape of the mastoid the former line is by no means constant, and as the varieties in the shape of the process bear no fixed relation to the varieties in the position of the sinus, it would be better to take some safe fixed line, such as that proposed.







SOME PRACTICAL CONSIDERATIONS  
ON THE  
ANATOMY OF THE MASTOID REGION,  
WITH GUIDES FOR OPERATING.\*

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I NEED not remind anyone of the wonderful advance made within recent years in brain localisation, or of the concomitant advance in brain topography and brain surgery. The improved localisation seems to have stimulated cerebral surgery, and to have brought new fields within the reach of the operating knife. On the other hand, the avidity with which the surgeon utilised the knowledge furnished in localisation and topography, has urged the physiologist and anatomist to further work in their spheres. Thus there has been a mutual stimulation, beneficial to the cause of surgery, of physiology, and of anatomy alike.

The condition which most frequently calls for operation on the brain is, I believe, abscess; and while it is a desirable thing to help in any way to remove this disease and its effects by operation, it is equally desirable to prevent its occurrence, if possible, by early treatment of the source or cause of most brain abscesses. For this reason the treatment of suppurative diseases of the middle ear (and particularly the radical treatment) has of late come into well-deserved prominence.

It will, I think, be admitted that the most fertile cause of brain abscess is suppurative disease of the middle ear. If this be so, surely it is wise to try by every means to cut short the course of, and, if possible, to eradicate, the disease of the ear, before it can set up intracranial mischief. The most generally adopted radical treatment of this condition seems to be free drainage of the tympanum. This is usually effected by opening into the mastoid

\* Read before the Section of Anatomy and Physiology, Royal Academy of Medicine in Ireland, on Friday, January 9, 1891.

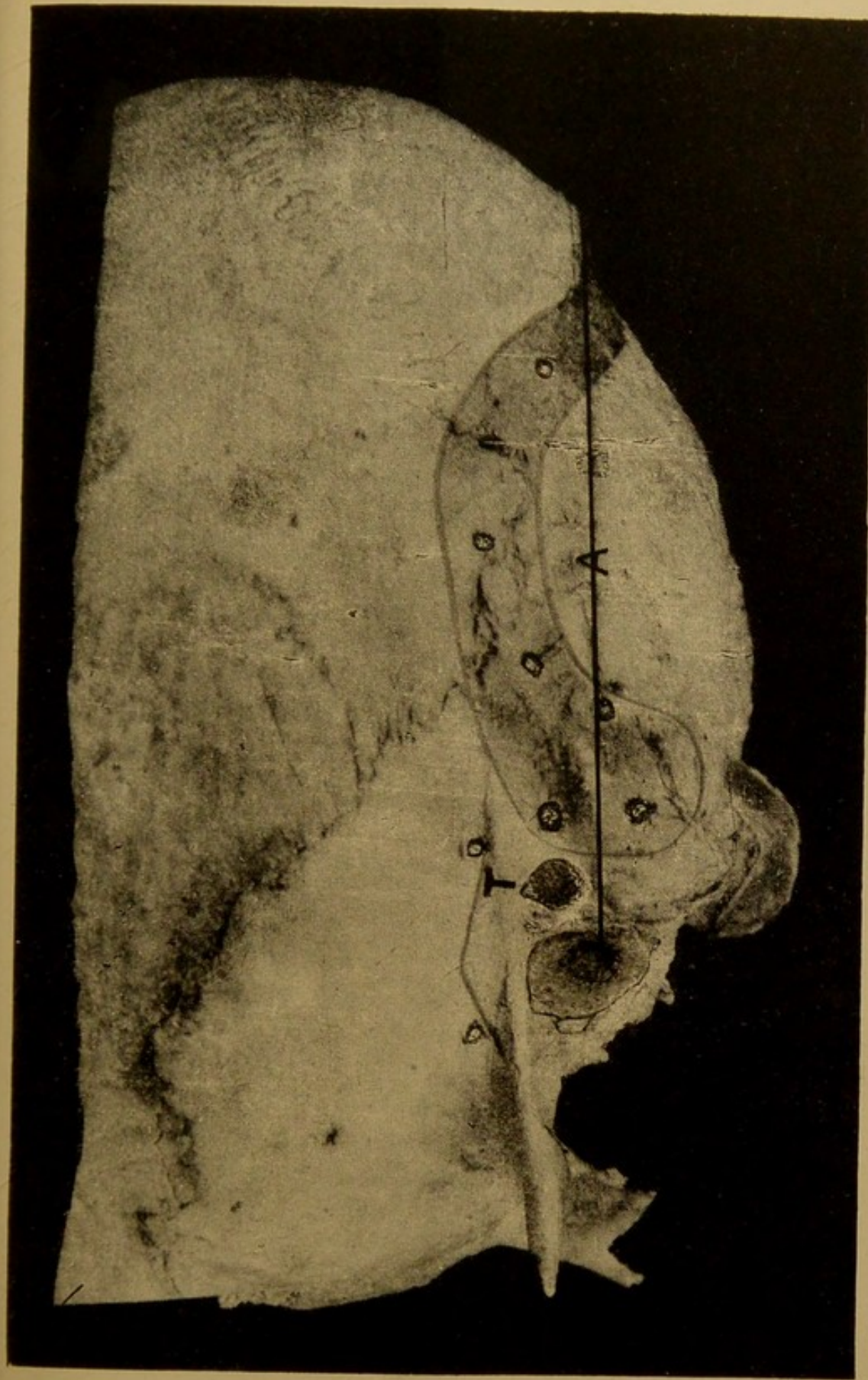


cells and antrum, which communicate so freely with the tympanic cavity, so that trephining or tapping the antrum is now a well-recognised operation, which has been attended with satisfactory results. Unfortunately, in a certain number of cases difficulties and dangers of a most serious nature arise in the operation, due chiefly to the complicated and varying anatomical relations of the part. The surgeon must approach an operation on the antrum with a certain amount of diffidence, for its intricate anatomy does not seem to have been thoroughly worked out—at least from the point of view of the operating surgeon.

In the hope of helping, even in a slight way, to elucidate the topography of the region, and of giving the operator more fixed data for working upon, I undertook an examination of the part early in 1890. With this object I collected and examined one hundred specimens. I communicated a preliminary report upon the matter to the Academy towards the end of last session; a full account of the investigation was read before the British Medical Association last year, and it will appear in the Transactions of the Academy for 1889-90. Since then I have studied the results of my examination, and have made some practical deductions, which I wish to place briefly before the Academy in this paper.

To make what follows more intelligible I may refer briefly to a few points in the anatomy of the region. The base of the pyramidal, petrous portion, of the temporal is applied to the inner surface of the conjoint mastoid and squamous portions of the bone. Below and in front, where the mastoid and squamous segments separate, is situated the external auditory meatus, which runs inwards and a little forwards towards the base of the petrous. At the bottom of the meatus is the tympanum or middle ear, separated by the membrana. From the upper and posterior portion of the tympanum (its attic) there runs backwards in the substance of the petrous the antrum mastoideum—a cavity which will usually contain a good-sized pea. Into it open the mastoid pneumatic cells, and it itself communicates freely with the upper part of the tympanum. The upper surface of the petrous forms part of the floor of the middle cranial fossa. Owing to the fact that the petrous may be applied to the squamous higher up or lower down than usual, the floor of the cranial cavity here may sometimes be a considerable distance above the upper margin of the bony meatus, while in other cases it is barely above the level of this margin. In perforating behind the meatus we must take care that we do





Part of Skull, showing quarter-inch drill hole into Mastoid Antrum. T, Drill hole; A, Base line.  
Lateral Sinus is also shown.







not enter the cranial cavity in a case where the petrous lies lower than usual. Again the lateral sinus runs downwards behind the ear in the angle between the back of the petrous and the inner surface of the mastoid; as will be shown later, the sinus comes forward in different skulls to a varying extent; sometimes it comes quite close to the meatus. Means must be found of avoiding the sinus in such cases. As to the point on the surface corresponding to the antrum internally, if the meatus runs inwards and a little forwards to the tympanum, and if the antrum runs backwards from the upper and posterior part of the tympanum, naturally a point immediately behind the meatus, and below the level of its upper border, ought to mark on the surface the position of the antrum. Such is always the case. Most measurements have been taken either from the bony meatus—its centre or margins, or from Reid's base line—viz., a line drawn backwards from the lower margin of the bony orbit through the middle of the meatus; posteriorly this line usually lies at the occipital protuberance, or immediately under it. It may be added that when working with *portions* of skulls, the upper margin of the zygoma may be considered practically horizontal in the normal position; this has been found a useful guide.

1. The first conclusion I have drawn is that the lateral sinus varies to an extreme degree in position and in shape. The surface markings usually given for mapping out its course are occasionally as much as an inch astray, and this at a point where there is danger of wounding the sinus in the operation of trephining for abscess, &c., of the temporo-sphenoidal lobe of the brain.

2. The following is the average condition of the sinus:—Beginning near the occipital protuberance, it ascends gradually, running forwards and upwards in close relation to the superior curved line for a short distance; leaving the curved line, it continues to arch upwards until it reaches a height of nearly  $\frac{3}{4}$  of an inch above Reid's base line; soon after it has reached this level the sinus bends gradually or sharply and runs downwards and forwards on the mastoid portion of the temporal immediately in front of a ridge which prolongs the posterior margin of the mastoid process upwards and backwards, and in front of the posterior margin of the process itself. Here it lies about  $\frac{1}{2}$  inch behind the meatus; having reached the level of  $\frac{1}{4}$  or  $\frac{1}{6}$  of an inch below the floor of the meatus, it turns in to the base of the skull. The bend of the sinus, where it begins to arch downwards, is most commonly at a



point  $1\frac{1}{2}$  inches behind and  $\frac{3}{4}$  inch above the centre of the bony meatus.

3. As a guide for avoiding the sinus in operations upon the cerebrum or cerebellum, I would suggest the following method for mapping out the limits within which it may wander:—One line should be drawn convex upwards from a point  $\frac{1}{2}$  an inch above the occipital protuberance to a point  $1\frac{1}{2}$  inches behind and  $1\frac{1}{4}$  inches above the centre of the meatus, another line from  $\frac{1}{2}$  inch below the occipital protuberance to the base line  $1\frac{1}{2}$  inches behind the meatus. Between these two lines the sinus will be found; above or below the space included between them trephining may be practised with safety.

4. I have also tried to arrive at some point at which the sinus might always be sought for with success; this is required in the operation for septic thrombosis of the sinus. Although it varies so much in its course generally, at one spot it is pretty constant in its relation to the middle of the meatus. If the pin of a  $\frac{3}{4}$  inch trephine be placed at a point  $1\frac{1}{8}$  inches behind the centre of the bony meatus, and on the level of its upper border, it will expose the sinus, I believe, in every case.

5. It has been the experience, at least, of some Dublin surgeons, that the site proposed by Mr. Barker for trephining in temporo-sphenoidal abscess—viz.,  $1\frac{1}{4}$  inches behind and above the centre of the meatus—occasionally brings the trephine down on the upper part of the bend of the lateral sinus. From an examination of my specimens I have come to the conclusion that the safest site for trephining over the temporo-sphenoidal lobe of the brain is such that the pin of the trephine shall be at a point  $1\frac{1}{4}$  behind and  $1\frac{3}{4}$ , or better still, 2 inches above the centre of the bony meatus.

6. In trephining over the cerebellum I would recommend that the pin of the trephine should be placed 1 inch below Reid's base line and 2 inches behind the centre of the meatus. This differs from the site proposed by Mr. Barker— $1\frac{1}{2}$  inches behind the centre of the meatus and 1 inch below the base line. I have found skulls in which the occipital artery would be wounded by a  $\frac{3}{4}$ -inch trephine placed as directed by Mr. Barker.

7. In all cases great care should be taken in boring the skull behind the ear, on account of the dangerous variations in the position of the lateral sinus; it is occasionally as little as  $\frac{1}{12}$  of an inch from the surface; in other cases it comes within  $\frac{3}{16}$ —less than a quarter of an inch of the back of the meatus.



8. With reference to tapping the antrum—after a careful examination of all my specimens, I have come to the conclusion that the mastoid antrum may be opened in every case, without wounding the sinus, and without opening the cranial cavity, if a  $\frac{1}{4}$ -inch drill be used, and sent straight inwards (without inclination backwards or forwards, upwards or downwards) at such a point that the hole it makes shall lie as near as possible to the back of the bony meatus, and its upper border not more than  $\frac{1}{12}$  of an inch above the level of a line prolonged backwards from the superior margin of the meatus. The instrument should not be driven in further than  $\frac{3}{4}$  of an inch at the most; if it be sent further than this distance there will be a danger—indeed, in a certain proportion of cases, almost a certainty of wounding the most external part of the labyrinth—viz., the external semicircular canal, which is in some cases not more than 17 mm. from the surface. The antrum will usually be reached at a depth of  $\frac{3}{5}$  of an inch. In about 98 per cent. of cases a  $\frac{1}{3}$ -inch drill might be used, and in a large proportion even a  $\frac{1}{2}$ -inch instrument; but since it is impossible to tell from the exterior the dangerous cases, the  $\frac{1}{4}$ -inch size should be used to secure safety in every case. The aperture may be subsequently enlarged with care, if this be thought necessary.

9. The attempt to open the antrum and the cranial cavity by one perforation, as proposed by Mr. Wheeler, will not always succeed. For if the trephine be placed in front of a vertical line passing through the most prominent part of the mastoid process, with its lower margin on the level of the upper border of the meatus, it will be found that the roof of the antrum is occasionally so low (as a consequence of the low level of the petrous portion of the temporal bone) that the trephine opening lies above the level of the antrum. From my experience I cannot recommend this method as a reliable means of reaching the antrum. If a  $\frac{3}{4}$ - or  $\frac{1}{2}$ -inch trephine be used, there must be great danger of wounding the lateral sinus, unless it be applied entirely above the level of the antrum. Under all circumstances it appears to me that a trephine—unless it be extremely small—is an objectionable instrument for tapping the antrum.

10. Finally, I would suggest a simple rule for avoiding the lateral sinus in this region—viz., that all deep perforations made here should be in front of a vertical line drawn  $\frac{1}{4}$ -inch behind the posterior margin of the meatus; and that they should be made with the greatest care. I have specially avoided giving any guides or



surface marks except bony points on the skull itself, about which there can be no doubt or uncertainty. The soft parts, such as the various divisions of the ear, &c., are too movable and too variable; they should never be adopted as reliable guides in such a critical corner with such important relations. I believe that in tapping the antrum the posterior and upper margin of the bony meatus ought always to be freely exposed, and all bearings taken with the greatest care from the meatus. The directions which I have suggested for reaching the antrum can be easily followed if the margins of the meatus be thus exposed.

I might point out, in passing, that the lateral sinus runs down on the mastoid, roughly, about opposite the line of reflection of the skin from the pinna on to the head posteriorly. I merely mention this because sometimes there is an idea held that the sinus lies a considerable distance behind this line.

These are the chief practical points which have occurred to me in connection with the topography of the region. I have said nothing about skin incisions, or about any of the earlier structures met with in operations on these parts; they are more properly the care of the surgeon.







