THE QUESTION OF INTRA-NASAL OPERATION UPON THE FRONTAL SINUS.*

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The advantages of drainage through the nose in cases of disease of the frontal sinus are, with the exception of the possibility of re-infection, so superior to the advantages gained by an external operation, that if a safe way could be devised by which the drainage in disease of the frontal sinus would follow its natural channel, we would have an immense improvement over our present method of operation. At the present time, the frontal sinus is approached by operations of greater or lesser magnitude, done through its anterior wall. This necessitates an incision through the skin, the cutting away of more or less of the bony wall, with the sure, subsequent disadvantage of a scar, and the possible, subsequent disadvantage of the formation of a depression as a result of the removal of the bony substance. The inconvenience of wearing a bandage, the disability to which the patient is subjected, and the tediousness of healing, are all elements which make the operation through the anterior wall a disadvantageous one. On the other hand, we know that a large percentage of frontal sinus cases recover spontaneously, and that external frontal sinus operations are comparatively infrequent. We also remember that the frontal sinus is unlike the other accessory sinuses of the nose, because its drainage opening is located at the very best possible position for perfect drainage. If one looks from above upon the floor of the frontal sinus, it is very much like looking down into a funnel. The whole of the floor inclines more or less abruptly towards the nasal frontal duct, in such a way as to facilitate drainage from the sinus. We all know that many cases of frontal sinus disease are cured by simply removing the obstructing element from the drainage opening. Sometimes this obstructing element is the swollen external wall of the middle turbinated body; sometimes it is the swollen tissue of the hiatus semilunaris, or of the adjacent processus uncinatus or bulla ethmoidalis; sometimes it is small polyp developed in this region. But whatever the cause, the frontal sinus responds nicely to treatment if it has free drainage, and if we have access to it, so that it may be irrigated.

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The distance from the floor of the frontal sinus through the nasal frontal duct is scarcely more than $\frac{1}{4}$ or $\frac{3}{8}$ of an inch; the distance from the end of the nasal frontal duct to the lower end of the bulla ethmoidalis (which marks the lower limit of possible obstruction of frontal sinus drainage) is not more than $\frac{3}{4}$ of an inch. Most of this region can easily be seen if the end of the middle turbinate has been removed. There remains a region of about $\frac{1}{2}$ inch, which includes the upper part of the hiatus semilunaris and the region of the nasal frontal duct, which is outside the range of vision. If it were possible to operate upon this region in such a way as to enlarge the opening into the frontal sinus sufficiently to secure thorough drainage and subsequent entrance with instruments, it would be possible for us to advocate an intra-nasal operation; and the object of my paper is to investigate the anatomical relations of this region, for the purpose of ascertaining if such a plan is justifiable. In considering these anatomical facts there are five points to which I would particularly ask your attention:

- (1.) That the frontal sinus may be absent.
- (2.) That the posterior wall of the frontal sinus, which supports the anterior lobe of the brain, may vary greatly in its height from the nasal frontal duct.
- (3.) That one is often mistaken in believing that he has entered the frontal sinus, when, as a matter of fact, his instrument is within an enlarged anterior ethmoid cell.
- (4.) That the direction and position of the nasal frontal duct varies considerably.
- (5.) That the olfactory fissure is an element of danger, in doing an intra-nasal operation.

(1.) THE ABSENCE OF THE FRONTAL SINUS.

No sinus gives such evidence of variation as the frontal sinus; it is not present until between the third and fifth years, and its development is probably interfered with by the early diseases of childhood or anything that produces mal-nutrition on the part of the child; it develops as a bud; which is shoved up from the nose into the region of the frontal bone, just behind that part of the frontal bone which articulates with the nasal bone and with the nasal process of the superior maxillary bone. The sketch from an actual case will illustrate the method of development of the frontal and the way the frontal sinus appears if it fails to develop. (Show dia-

gram: specimen 14, skull 95.) In this case the frontal sinus is absent; the hiatus semilunaris ends in the blind pouch, but this pouch extends behind the nasal frontal superior maxillary suture, two millimeters above their point of junction. This undeveloped frontal sinus is eight millimeters from the anterior surface of the frontal bone; the width of the pouch is four millimeters.

The naso-fronto superior maxillary suture spoken of above is the point upon the skull where the frontal bone joins with the nasal bone internally and the nasal process with the superior maxillary externally. This makes a "T" shaped suture, which can sometimes be felt, and is always easily demonstrated. It is a sure guide to the level of the floor of the frontal sinus and marks the course of the

Cut No. 1

Diagram of skull 95. Shaded part is the Hiatus Semilunaris and undeveloped frontal sinus. 1. Anterior cerebral fossa. 2. Processus Uncinatus. 3. Bulla Ethmoidalis.

nasal frontal duct. This important landmark should not be forgotten in case of abnormalities in frontal sinus work. Sometimes, as I have said, the frontal sinus does not develop. In such cases an operator attempting to enlarge the opening into the frontal sinus from the nose, would meet with difficulty and possibly run into danger, because he would not be able to find the sinus. But this danger would not be greater in the intra-nasal operation than in the operation done from the outside. In other cases, the frontal sinus is very small, and in such cases the operator attempting to curette the sinus or enlarge the opening sufficiently for satisfactory drainage might do injury to the brain through the region which will be mentioned later on.

(2.) A LOW POSTERIOR WALL, OR LOW ROOF, OF THE FRONTAL SINUS:

When the naso-frontal duct has been opened and the cutting instruments continue to be used, the point which is next attacked by the instrument is *not* the anterior wall, but the *posterior* wall of the frontal sinus. This is explained by a view of cut 2, which shows that the bent probe passed into the frontal sinus takes a direction towards its anterior wall, but that a straight instrument which has been cutting away the region of the nasal frontal duct next attacks the posterior wall, which is the support for the brain. This roof, or posterior wall, of the frontal sinus supports the anterior lobe of the brain. It begins above, where it meets the anterior wall of the sinus, and extends concavely back-

Cut No. 2

Diagram of bent probe in Frontal Sinus. A straight cutting instrument would approach the brain wall rather than move away from it.

ward to the posterior limit of the frontal sinus. It thus forms both the posterior wall and the roof. In some cases, this posterior wall is scarcely concave; in other cases, it is markedly concave. So far as I know there is no rule by which the concavity of this wall may be determined by external examination. If the sinus is large and the posterior wall not markedly concave, the perpendicular distance between this wall and the nasal frontal duct is considerable. But if the sinus is small, or if the posterior wall dips into the sinus considerably, the distance from the nasal frontal duct to the posterior wall is very short. In a series of two hundred skulls which I measured, to ascertain the average distance between the nasal frontal duct and a point perpendicularly opposite on the posterior

wall, I found that the distance varied from four to forty millimeters—that is, from 1-6 to $1\frac{1}{2}$ inches. With this vast difference of distance between the nasal frontal duct and the wall which supports the brain directly opposite it, it will readily be perceived that in some cases an intra-nasal operation could be done with perfect safety, but in other cases any operation done intra-nasally might result in the perforation of the posterior wall and subsequent involvement of the brain. Some interesting measurements are given in a table which is here appended, showing the relative distance in millimeters of points which have a bearing upon the surgical topography of the frontal sinus.

Cut No. 3

Longitudinal section of Ethmoid Cell invading the space of Frontal Sinus. 1. Ethmoid Cell developed in Frontal Sinus space. 2. Frontal Sinus. The arrow is in the naso-frontal duct.

(3.) MISTAKING AN ANTERIOR ETHMOIDAL CELL FOR THE SINUS:

If the frontal sinus is absent, an anterior ethmoidal cell often attempts to compensate for the absence of the sinus by an unusually extensive development forward and upwards. Sometimes an anterior ethmoid cell will enter the region of the frontal bone and will simulate a small frontal sinus. The nasal measurements with the probe will be about the same, and the skiagraph alone can distinguish the fact that the probe does not lie against the anterior wall of the frontal bone. Sometimes, when the frontal sinus is small, a similar over-development of one of the anterior ethmoid cells occurs. In such cases, this ethmoid cell extends upward, along the side of the nasal frontal duct and spreads out within the frontal bone, externally to the naso-frontal duct (Cut 3). In a few cases I

have found that the ethmoid cell may extend upward to the inner or median side of the nasal frontal duct. The importance of this observation is at once apparent, for if an intra-nasal operation is attempted and the instrument is allowed to work within the enlarged ethmoid cell under the belief that it is in the frontal sinus, a perforation of the brain plate would easily result, even though the instrument were working in a small frontal sinus. This, of course, is easy to understand, from the fact that the roof of all the ethmoid

Cut No. 4. (Viewed from below.)

1. Articulation of superior maxillary bone.
2. Articulation of nasal bone.
3. Olfactory fissure.
4. Naso-frontal duct.

Cut No. 5. (Viewed from above.)

1. Projection for support of nasal bone.
3. Olfactory fissure.
4. Naso-frontal duct.

cells is always much lower than the roof of the frontal sinus; because, in a normal case the level of the roof of the ethmoid is about the level of the floor of the frontal sinus. The danger of intra-nasal work is therefore one of danger of perforation of the brain; and from what has already been said, it can also be safely assumed that even if we have been in the habit of washing out a cavity with an irrigating syringe repeatedly, it would not be safe for us to use a cutting instrument within the same region. But this is more clearly emphasized when we study the next point; viz.:

(4.) THE RELATION OF THE NASO-FRONTAL DUCT TO THE OLFACTORY FISSURE.

A glance at the boundaries of the nasal frontal duct is now necessary for a thorough understanding of this point. The diagrams Cuts 4 and 5) show the relations of the nasal frontal duct throughout, from above. The first one shows that the nasal frontal duct is directly behind the suture made by the frontal bone, the nasal process of the superior maxillary bone and the nasal bone; or, to speak more exactly, the nasal frontal duct itself is immediately behind the nasal process of the superior maxillary bone. The distance from this process to the nasal frontal duct is generally about eight millimeters. This duct, then, is bounded in front by the nasal process of the superior maxillary bone; it is bounded on its orbital side by a part of one of the anterior ethmoid cells; it is bounded behind by an anterior ethmoid cell; and on its median side by the olfactory fissure, from which it is separated only by a thin plate of bone scarcely a millimeter in thickness. This olfactory fissure is composed of two sulci—an anterior one, which serves for the passage of the nasal nerve and artery, and the posterior one for the passage of the olfactory nerve. This olfactory fissure is a communicating foramen between the brain and the nose. It is separated from the nasal frontal duct, which lies external to its anterior part, as I have said before, by the very thinnest possible bone plate, scarcely a millimeter in thickness. If the continuation of this bone is examined it will be found that this plate of bone between the naso-frontal duct and the olfactory fissure is the processus uncinatus, which plays such an important part in the anatomy of the middle meatus. It does not require a mental prodigy to see that the operator in working in the upper region of the nasal frontal duct, just at the floor of the frontal sinus, is in constant danger of destroying the inner wall of the nasal frontal duct, by cutting away the extreme base of the processus uncinatus, and that the moment this is done, the operator has entered the olfactory fissure and is on a direct line of communication with the brain cavity, and in danger of producing a traumatism of the brain or septic meningitis.

(5.) I have now stated four reasons why the intra-nasal operation is practically impossible and, under certain conditions, entirely unsafe.

The fifth reason why it should not be done is on account of certain variations in the locality and direction of the nasal frontal duct. Specimens have been seen (see cuts) where the nasal frontal duct instead of opening at the anterior end of the hiatus semilunaris, as it ordinarily does, opens at the point posterior to this. Indeed, in some

cases, the nasal frontal duct opens into the nose on a line with the opening of the bulla ethmoidalis. This is considerably behind the usual opening of the duct—(four or five millimeters) 1-5 of an inch. When the duct opens more posteriorly than usual, its obliqueness is more marked and the danger of working upward is increased, the obliqueness of the duct bringing the brain wall nearer the nose. It has also been observed that in young frontal sinuses the duct is more oblique than in fully developed skulls. This is a matter of importance, as it increases the danger of operating upon young adults.

These five reasons are sufficient to show some of the difficulties and dangers which may be encountered in intra-nasal operation. The two greatest dangers are the second and fourth, viz: the low roof of the frontal sinus, which brings the brain plate very near the nasal frontal duct, and a slight deviation of the instrument towards the median line, which will bring this instrument into the region of the olfactory fissure and will allow an instant perforation. In cadaver work, where I have repeatedly attempted to perform a safe intra-nasal operation, it has invariably been one of these two conditions which has caused a perforation of the brain plate. I do not wish you to understand that I believe for an instant that no case of frontal sinus disease may be treated by intra-nasal operation—since we all know cases which have been brilliantly handled in this way. My own clinical experience and my experience with work on the cadaver, in searching for a safe intra-nasal operation, have shown me that the result of intra-nasal surgery, on the frontal sinus is often brilliant; but on the other hand, perforation of the brain has occurred under most careful operative procedure, in cases where it was beyond my control to prevent it, although the percentage of these perforations was not larger than one-third. Still, if this number of perforations were carried into clinical experience, with the almost invariably fatal results, it would hardly justify our ever doing any frontal sinus operations intra-nasally.

By this time, you have undoubtedly received the impression that I consider all attempts to operate on the frontal sinus from the nose as unjustifiable and dangerous, notwithstanding the brilliant results which we sometimes see in our own work and that of our colleagues; and yet, it is hardly the province of the critic to tear down a structure without offering something as a substitute for the parts which he has demolished; and nothing is to be gained by condemnation unless another and better structure is to rise in its place. The question before us now is, whether it is not possible to devise some means of operation upon the frontal sinus in a safe way without producing

as much scar or deformity as one ordinarily produces from an external operation. In trying to build up a new structure in place of that which I have destroyed, I must acknowledge that my experience in this matter and with the technique which I am to propose, has been derived entirely from the theoretical study of anatomy and the operative work on the cadaver. As yet, I have not had an opportunity to apply this knowledge or the results of my cadaver experience, on the living subject, but it seems to me justifiable to propose what I have, hoping that someone else may have had a larger opportunity to develop the practical side of the suggestion than I have.

The problem is to reach the floor of the frontal sinus, which lies away from the brain, in a safe way, and yet in a way which will destroy the anterior part of the floor of the sinus without reaching the dangerous posterior wall. In other words, while all the attempts heretofore have been to enlarge the opening of the frontal sinus by cutting out the posterior wall of the nasal frontal duct, and with it the associated ethmoid cell, the question now is how to reach and destroy the anterior edge of the processus uncinatus, the anterior wall of the nasal frontal duct and that nipple or ridge of bone which projects from the anterior wall of the frontal sinus, making a part of the frontal sinus floor and receiving the base of the nasal bone on its articulating surface. (See cut 5.)

If we introduce a cutting instrument with the idea of opening the floor of the frontal sinus and place this cutting instrument against the junction of the middle turbinated body with the outer nasal wall, and then cut upward and slightly outward, we will not destroy any part of the frontal sinus, but will cut into the lachrymal duct, the upper end of which lies against the attachment of the middle turbinated body to the external nasal wall. (See cut.) If the cutting instrument is carried two millimeters (2-5 of an inch) further posteriorly, so as to lie external to the middle turbinated body, it will reach the hiatus semilunaris, and by cutting slightly forward will remove the posterior edge of the processus uncinatus. The processus uncinatus is ordinarily five millimeters wide, so that by cutting 1-5 of an inch anterior the whole width of the processus may be removed. If the instrument is now turned slightly upwards, forwards, and very slightly inward, it will lie in such a position that it will grasp the base of the processus uncinatus, which, I have shown before in Cut 4, lies just internal to the nasal frontal duct and external to the olfactory fissure. The safety of the next bite of the forceps depends now on whether the forceps cut out or inwards, for if they are inclined inward, they will enter the olfactory fissure;

if outward, they will destroy the nasal frontal duct and the ethmoid cell and enter the frontal sinus through its floor. If, instead of directing the instrument in this way, it is directed from the base of the processus uncinatus, slightly inward, it will cut through the processus uncinatus and continue up its median surface to the olfactory groove and through to the brain. It is of decided advantage to have the middle turbinate unamputated, for by keeping well external to the middle turbinate, the danger of opening the olfactory fissure is diminished.

If now we approach the study of the anterior part of the floor of the frontal sinus, it will be seen that the solid, bony projection, which I have before called a nipple or ridge of bone forms a large part of the floor of the frontal sinus in front, near its median line. This bony ridge or nipple is a part of the frontal bone and lies directly behind the nasal frontal superior maxillary articulation (See cut 5), and serves not only to support the nasal bone and the nasal process of the superior maxillary, but on its frontal sinus side, when all parts are normal, there is a kind of fusion at this point of the base of the processus uncinatus and the nasal attachment of the middle turbinate. This ridge is of considerable width, and occupies the floor of the frontal sinus from 4 or 7 or 12 millimeters in width. It can thus readily be seen that if this bony process could be destroyed a considerable space for drainage could be gained by the destruction of such a part of the floor; and it could all be accomplished without coming in contact anywhere with the posterior wall of the sinus. (See cut 5.) That is, an opening of 4 to 7 millimeters could be gained. Another point in favor of the destruction of this part is, that if it is attempted from the nose the direction of all the instruments would require an angle anterior of about 45 degrees; and this would bring the instruments directly away from the posterior wall. It is also possible, if it is found necessary, to use a chisel to remove this part, introducing a protector within the nasal frontal duct which would prevent wounding the posterior wall. In order to remove this part (it is necessary for us to use cutting instruments, working at an angle forward of about 45 degrees, and externally at an obliqueness of about 5 degrees from the perpendicular. This corresponds roughly to the angle made between the base of the nasal bone and the frontal bone. This external angle forms a rough and ready means of determining the direction of the instruments when used internally.

I have satisfied myself, after many cadaver operations, that this is a fairly safe operation to do, but occasionally, I have had a perforation of the brain result from *this* operation.

There is, however, another way to destroy this part, which can be done with absolute safety and with surgical precision: That is, to destroy this nipple or ridge of bone on the floor of the frontal sinus through an external incision, which need not produce a marked scar and which may be closed up immediately after operation. This operation is performed in the following way:

Cut No. 6

Frontal Sinus and Ethmoid operation. Lateral view showing destruction of floor of frontal sinus.

An incision is made $1\frac{1}{2}$ cm. long, part way between the inner canthus of the eye and the medial line of the nose. This incision should extend an equal distance each side of the line from the inner canthus. A periosteotome should be used to separate the soft parts from the bone and the suture between the form by the frontal bone, the nasal bone and the nasal processus of the superior maxillary

bone should be found. This naso fronto superior maxillary suture, as we have already said, is "T" shaped. It is always easily demonstrated and when found is a guide to our opening. A small trephine or chisel is now used to make an incision through the bone, the center of the incision being the center of this suture. The trephine has perforated through the base of the nasal bone, a bit of the nasal process of the superior maxillary, and this part or ridge of the frontal bone which supports these two structures.

Cut No. 7

Frontal Sinus and Ethmoid operation performed through small external opening. Viewed slightly sideways showing destruction of floor of frontal sinus.

After the trephine has penetrated about seven millimeters, a cavity will be reached. This cavity will be the nasal frontal duct, or the space of the frontal sinus. But in case these structures are absent, by continuing a short course further back, the operator will enter the nose. As soon as the instrument is felt to be within a free space, it should be removed, the plug of bone taken away and a probe used to demonstrate the sinus. Through this opening, with a fine chisel the anterior wall of the nasal frontal duct may be destroyed and a

considerable opening made from the sinus into the nose. It is possible to curette the anterior ethmoid cells through this opening; or, if they are diseased, this may also be done at the same time by a combined method through the trephine opening and through the external nose. The first step should be, in all cases to remove the anterior tip of the middle turbinated body. After curettage has been completed, the region should be cleansed and washed, the frontal sinus packed with gauze (which is afterwards to be removed from the nose), and the wound is to be closed up with sutures. The packing should be removed at the end of three days and the sinus very carefully irrigated, if it contains any pus. (Cuts 6 and 7.)

The accompanying cuts show sketches made from an actual specimen on which operation was performed, and where the ethmoid cells were curetted through the trephine opening. It shows very well how completely the floor of the nose has been taken away, how perfect the drainage will be, and also the possibility of operating on the anterior ethmoid cells by this combined method.

The five points in this paper are:

- (1) That the frontal sinus may be absent.
 - (2) That the posterior wall of the frontal sinus which supports the anterior lobe of the brain may vary from 4 to 40 m. from the nasal frontal duct.
 - (3) That the investigator is mistaken in believing that he has entered the frontal sinus when, as a matter of fact, he has entered an ethmoid cell. Operations conducted under this belief are dangerous, for the roof of an ethmoid cell are only on a level with the frontal sinus.
 - (4) The directions and position of the nasal frontal duct vary considerably, and if varied, are more oblique. Obliquity of the duct increases the danger of intra-nasal operation and brings the posterior wall nearer the nasal frontal duct.
 - (5) That the olfactory fissure is an element of danger.
-