Superficial surgical landmarks for the frontal sinus

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Object. There is a lack of reports in the literature that contain descriptions of superficial anatomical landmarks for the identification of the internally located frontal sinus. Neurosurgeons must often enter the cranium through the frontal bone and knowledge of the frontal sinus is essential to minimize complications.

Methods. Seventy adult cadaveric frontal sinuses were evaluated. Measurements included both the lateral and superior extent of the frontal sinus in reference to a midpupillary line, and the superior extent of the frontal sinus from the nasion. Frontal sinuses were found bilaterally in all specimens. The mean height of the frontal sinus superior to the nasion was 2.8 cm. In 71.4% and 74.3% of specimens the lateral extent of the frontal sinus was found to be medial to the left and right midpupillary line, respectively. Distances superior to a plane drawn through the supraorbital ridges at a midpupillary line included a mean of 2.5 mm for the left side and 1.8 mm for the right side.

Conclusions. Of 70 sinuses, none extended more than 5 mm lateral to a midpupillary line. At this same midpupillary line and at a plane drawn through the supraorbital ridges, the frontal sinus was never higher than 12 mm. Finally, in the midline the frontal sinus never reached more than 4 cm above the nasion. These measurements will assist surgeons who must manipulate the frontal bone.

Key Words • anatomical study • frontal sinus • paranasal sinus

The frontal bone must be traversed for many procedures. Although the frontal sinus has been described many times, details about superficial surgical landmarks that are useful for avoiding entering these cavities are lacking in the literature. Not only procedures involving frontal craniotomies, but also tasks such as Mayfield pin placement and emergency supraorbital ventricular puncture, necessitate knowledge of frontal sinus anatomy to minimize morbidity. Localizing the frontal sinus is also occasionally necessary for the neurosurgeon who wishes to enter it as a means of entering the anterior cranial fossa. Some have advocated the use of radiographically derived templates of the frontal sinuses for surgical localization of these structures.

Materials and Methods

Thirty-five adult human cadavers were used; their ages at death were not available but most specimens were obtained from elderly persons. Twenty specimens were male and 15 were female; all were caucasian. Each specimen was dissected in the frontal region down to the frontal bone. This entailed removal of the overlying soft tissue, that is, skin, fascia, musculature, and periosteum overlying the frontal bone, from the nasion inferiorly to the coronal suture superiorly. Next, with a hand drill, holes were placed approximately 2 mm superior and approximately 2 mm lateral to the nasion. Once the frontal sinus was entered, rongeurs were used to find the superior and lateral extent of each sinus. These boundaries on each side of each specimen were then referenced to various superficial anatomical landmarks. Distances were measured from the aforementioned boundaries of each sinus to a horizontal line connecting the left and right supraorbital ridge, the midpupillary line of each eye, and the distance above the nasion in the midsagittal plane. The majority of sinuses evaluated were asymmetrically divided into left and right sides; therefore, the height above the nasion is referred to as the “distance to the superior extent of the frontal sinus,” which does not imply left or right side in the midsagittal plane. All distances were measured with calipers. Figure 1 illustrates all measurements made and Table 1 summarizes these measurements.

Results

All specimens contained a frontal sinus bilaterally, and none was noted to have a gross pathological condition, such as fracture or hyperostosis, in the frontal sinus area. No specimen had a persistent metopic suture and all crania were thought to be normocephalic. No ocular or extraocular pathological condition was noted. Grossly, no pronounced surface anatomy such as the glabella or superciliary arch was found to correlate with the presence or size of the sinus. Results showed no significant difference between sexes or sides (p < 0.05). Only two specimens (5.7%) had a midline septation that divided the left from the right frontal sinus. Three sinuses (8.6%) had additional septations that were horizontal in nature, and these were all found in the left portion of the sinus.

As shown in Fig. 1, the measurements from the nasion to the superior border of the frontal sinus ranged from 2 to 4 cm with a mean and median of 2.8 and 3 cm, respectively. On the left sides, in two specimens (5.7%) the lateral extent of the frontal sinus was on the midpupillary line, in 25 (71.4%) the lateral extent of the sinus was medial to this line (range 1.8–9 mm, mean 3 mm, median 2.8 mm), and
Frontal sinus landmarks

![Schematic drawing showing the planes on which the sinuses were measured. A: Horizontal line connecting the supraorbital ridges. B: Midpupillary line. C: Superior extent of frontal sinus from the nasion in the midsagittal plane.](image)

<table>
<thead>
<tr>
<th>Landmark Description</th>
<th>Distance</th>
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<tr>
<td>nasion to sup border of FS (midsagittal plane)</td>
<td>2–4 cm (mean 2.8 cm, median 3 cm)</td>
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<tr>
<td>lat extent of FS at MPL</td>
<td>It sides: 2 on MPL, 25 medial (1.8–9 mm, mean 3 mm, median 2.8 mm); 8 lat (2–5 mm, mean 2.5 mm, median 3.5 mm)</td>
</tr>
<tr>
<td>rt sides: 1 on MPL, 26 medial (2–15 mm, mean 3.5 mm, median 3.1 mm); 8 lat (1–4 mm, mean 1.9 mm, median 2.8 mm)</td>
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</tr>
<tr>
<td>FS sup to supraorbital ridges at MPL</td>
<td>It sides: 0–12 mm (mean 2.5 mm, median 3.4 mm)</td>
</tr>
<tr>
<td>rt sides: 0–9 mm (mean 1.8 mm, median 3 mm)</td>
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* FS = frontal sinus; MPL = midpupillary line; sup = superior.

Discussion

The frontal sinus is one of four major paranasal sinuses. As summarized by Asherson, these were first drawn by da Vinci and first described by Coiter (1534–1576). These sinuses may be rudimentary, absent, or extend through most of the lower half of the frontal bone. Currently, our insight into the function of these structures is speculative rather than known. They are routinely described in the adult as pyramidal in general shape, can be composed of a vertical portion that is more anteriorly located and a horizontal portion that is more posteriorly located, and can extend into the orbital roof 1 to 2 cm. The frontal sinuses occur in approximately 85 to 95% of the adult human population and are not found in the phylogenetic scale below the mammalian level. Among primates, only the African great apes and humans possess frontal sinuses. The development of these structures also varies among different races. For example, in Eskimos they are found to be aplastic in 52% of adults. Asymmetry of the sinuses is more common in dolicocephalic than in brachiocephalic or mesocephalic individuals. These irregular cavities extend within the inner and outer table of the frontal bone in many dimensions, and have been said to be so individually specific that some have advocated their use in forensic identification.

There is controversy as to whether there are external indications for the location of the frontal sinus. Both Asherson and Schaeffer have stated that the external frontal bone shows no markings for the internally located frontal sinus. Others have indicated, however, that the frontal sinus may be somewhat internally marked by the glabella, and that as the volume of the frontal sinuses increases the protuberance of the glabella increases. Other nonspecific locations of the frontal sinuses have been mentioned in the literature. Deaver and Fyfe and Hooper described them as usually lying in a plane between the superciliary eminences. Reports in the literature vary with respect to the height and width of the frontal sinuses. The so-called normal heights and widths have been reported to be between 2.43 and 6.6 cm and between 1.7 and 4.9 cm, respectively.

We have found that in 35 cadavers the superior extent of the frontal sinus in the midsagittal plane was never more than 4 cm superior to the nasion and had a mean distance of 2.8 cm. The highest point of the frontal sinus was medially located in all specimens and in all sinuses both left and right sides tapered laterally to give the structures their classic pyramidal shape. Only eight left and eight right frontal sinuses crossed the midpupillary line laterally and the means for the measurement for left and right sides were 2.5 and 1.9 mm, respectively. Finally, the mean heights superior to the supraorbital ridges at the midpupillary line for left and right sides were 2.5 and 1.8 mm, respectively.

These results were obtained from adult specimens and would not apply to children or adults with diseases that alter frontal sinus anatomy, such as large frontal sinuses associated with acromegaly and small sinuses associated with Apert syndrome. In a radiographic study, Siedband has stated that in a 3-year-old child the frontal sinus can be found 3.8 mm superior to the nasion and that the structures will ascend approximately 1.5 mm each year until the age of 15 years, at which time they have reached an adult state.

Although electrical transillumination was originally attempted for localizing and defining the borders of the frontal sinuses in our study, it was soon evident that this was of little use in the cadaveric specimens examined. In fact,
Schaeffer\textsuperscript{9} has noted that this method frequently fails to provide the clinician with accurate boundaries for the frontal sinus. Radiographically derived templates would be more precise for outlining the frontal sinuses on a case-by-case basis. Our measurements would be of utility, however, as general guides and when templates were not available. We hope that the external landmarks with measurements provided in our study will prove useful to the surgeon who wishes to localize the internal position of the frontal sinus.

Conclusions
We have found that the frontal sinuses never crossed the midpupillary line more than 5 mm laterally and were routinely no more than 4 cm (mean 2.8 cm) superior to the nasion. In addition, heights superior to the supraorbital ridges at the midpupillary lines were no more than 12 mm. These external landmarks would not be useful in children or in adults with diseased structures, but should offer the surgeon adequate superficial landmarks for the frontal sinus in the majority of cases.

References

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