Rhinology, 19, 195–202, 1981

Bony defects and dehiscences of the roof of the ethmoid cells

Toshio Ohnishi, Tokyo, Japan

SUMMARY

Endonasal sinusectomy is one of the most useful operations for treatment of chronic sinusitis. A previous study by the author on the incidence of complications of sinusectomy revealed that injuries to the base of the skull occurred in 0.15% and acute meningitis in 0.01% in a total of 450,000 sinus operations performed in Japan. In the present study a close observation of 17 (34 sides) skull specimens by the operating microscope revealed five major dangerous areas in the roof of the ethmoid sinus where anatomical structures present unusual vulnerability to injury during operations because of dehiscences and bony defects.

The author found frequent bony dehiscences, where submucous connective tissue was in direct contact with the dura mater and also unusual structure of intimate adhesions between the bone and connective tissue of the dura mater.

It is stressed that utmost care should be used in the operation of the ethmoid sinus and that microscopic surgery is a useful means for meticulous surgery and for prevention of side injuries.

The topographical anatomy of the upper paranasal sinuses is quite variable and complicated. It is also fraught with individual variations. Surgery of the paranasal sinuses has to deal with such labyrinth of the upper sinus groups, which are in close proximity to the important organs and structures e.g. the eyeball, ocular muscles, optic nerve, internal caroid artery, dura mater, and brain.

Injuries to any wall of the ethmoid sinus during surgery may entail serious complications. The purpose of the present paper is to delineate the dangerous areas in the roof of the ethmoid cells and to present information which would be useful for both macroscopic and microscopic surgery of the paranasal sinuses. This study was carried out based on a close microscopic observation of the roof of the ethmoid cells.

METHOD

A total of 17 block specimens containing the right and left ethmoid sinuses from 17 cadavers, 10 males and 7 females, ranging in age from 48 to 82 years were prepared for operating microscopic observations of the structure of the roof of the

ethmoid cells by removing all the contents of the sinus cavities and the dura mater overlying the bony roof.
The structure of the bony roof of the ethmoid cells was studied carefully by means of an operating microscope for unusual rarefaction of the bony plate, bony dehiscences and defects.

RESULTS

The ethmoid cells can be divided into two major compartments, a. the anterior ethmoid cells and b. the posterior ethmoid cells. The wall between the two is the third ground lamella. The anterior ethmoid nerve usually runs along the base of the ground lamella. The roof of the ethmoid cells consists of a part of the frontal bone, which is an extended plate of the posterior wall of the frontal sinus. Microscopic observation of the bony roof of the ethmoid cells revealed a rough and uneven surface both on the ethmoid sinus side and on the cranial side. Furthermore, the thickness of the bony plate was found to be quite varied at different sites. The present study demonstrated five different areas of the roof of the ethmoid cells where the bony plate was unusually thin and, at the same time, often showed defects and/or dehiscences. In such areas, the submucous connective tissue lining the sinus walls is directly in contact with the connective tissue of the dura mater.
Any injury that is caused by surgical instruments to such areas seems likely to produce an open pathway for the organisms into the intracranium or leakage of the cerebrospinal fluid from the subarachnoid space.
The five areas demonstrated are:

1. the medial wall of the ethmoid sinus
2. the area along the course of the anterior ethmoid nerve
3. the area about the origin of the middle turbinate
4. the antero-lateral aspect of the roof of the ethmoid cells
5. the area about the foramen of the posterior ethmoid nerve.

The location of the above critical areas are illustrated in Figure 1.

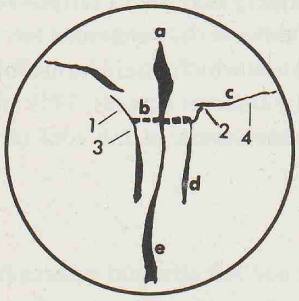

Figure 1.
Schematic illustration of the dangerous areas;
1. medial wall of the ethmoid sinus,
2. the area along the course of the anterior ethmoid nerve,
3. the area about the origin of the middle turbinate,
4. the antero-lateral aspects of the roof of the ethmoid cells,
   a. crista galli,
   b. cribriform plate,
   c. roof of the ethmoid sinus,
   d. middle nasal turbinate,
   e. nasal septum.

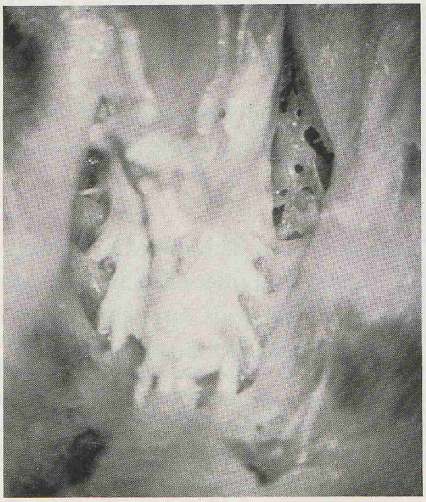

Figure 2. Several bone dehiscences or defects in the medial wall of the ethmoid sinus. (a view from above)

Figure 3. Several bone dehiscences or defects in the medial wall of the ethmoid sinus. (a view from below)

1. The medial wall of the ethmoid sinus is the area pointed out by Halle in 1927 and by Takahashi in 1944. This is a very thin medial bony wall of the ethmoid sinus illustrated in Figures 2 and 3. The bony wall is in the same plane with the middle turbinate, but it is located above the level of the cribriform plate (Figure 1). This bony wall which is present usually at the anterior and middle part of the ethmoid sinus is very thin and often perforated with bony dehiscences other than the foramen of the anterior ethmoid nerve.

This area, though often taken for a laterally extended plate of the cribriform plate when studied on dry skulls, is not perforated by the olfactory nerves as seen in Fig. 2 and is considered to be of a different entity from the cribriform plate. The medial wall of the ethmoid sinus is lacking in some cases where the ceiling of the ethmoid sinus is relatively low, as the medial wall forms the roof of the ethmoid cells. The bony roof, in such instances, is rather thick and usually without rarefaction of the bone.

The cribriform plate has often been cited as the most frequent portal of the infection into the intracranium. The cribriform plate is however, medial to the middle turbinate, therefore, it can not be injured without breaking the middle turbinate beforehand during ethmoidectomy. Furthermore, the cribriform plate is a thick bony wall which would not be easily destroyed by simple manipulation. Contrary to many previous statements that the cribriform plate had been the most frequent site of injury during sinus surgery and the most frequent site of pathway for intra-

cranial infections, the present study implied that the thin and fragile medial wall of the ethmoid sinus with frequent bony dehiscences might be responsible for such claims instead.
Rarefaction of the bone at the medial wall of the ethmoid sinus was seen in 13 out of 34 sinuses studied or in 38%. Bony dehiscences and/or defects were seen in 5 out of the 34 sinuses or in 14%.

2. The area along the course of the anterior ethmoid nerve. The anterior ethmoid nerve is a branch of the nasociliary nerve that divides from the inferior trochlear nerve. The anterior ethmoid nerve enters the ethmoid sinus from the medial wall of the orbit and runs along the roof of the sinus medially then enters the cranium at the base of the middle turbinate.
The nerve takes various routes in relation to the roof of the ethmoid sinus e.g. inferiorly or, within the bony plate through a complete tunnel or superiorly.
In some cases, the nerve is exposed to the sinus cavity, in other cases when the bony plate is particularly thin, there may be a fissure in the bony plate of the ethmoid roof along the course of the nerve as shown in Figure 5. The bony wall along the course of the anterior ethmoid nerve has been found to be uneven and thin with occasional small bony defects and dehiscences. Such bony defects were confirmed in 4 out of 34 sinuses or in 11% and rarefactions of the bony plate were seen in 12 out of 34 sinuses or in 35%.

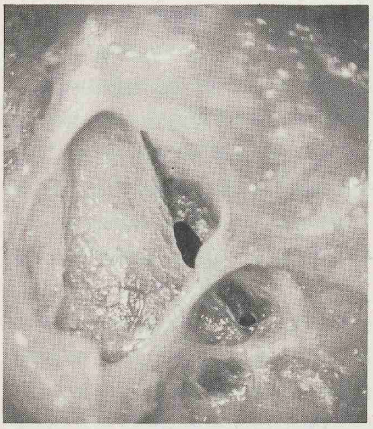

Figure 4. Several bone dehiscences or defects around the anterior ethmoid nerve foramen. (a view from below)

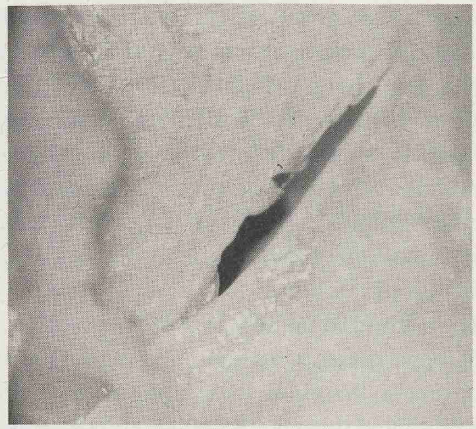

Figure 5. The anterior ethmoid nerve and a bone fissure along the entire course of the nerve in the roof of the ethmoid sinus. (a view of the left ethmoid sinus roof from below)

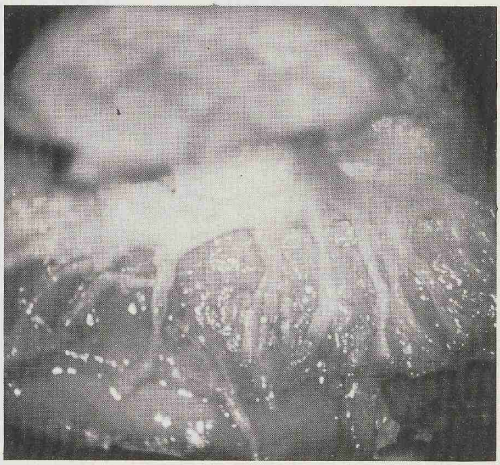

Figure 6. Many branches of the olfactory nerve on the medial wall of the bony middle nasal turbinate and the dura mater.

3. The upper part of the middle nasal turbinate.
The middle nasal turbinate, when observed from its lateral aspect, is found to have an abundant distribution of the olfactory nerves on the medial aspect of the bony turbinate which is quite thin and semi-transparent.
The olfactory filaments enter the nasal cavity through many small perforations in the cribriform plate.
The pathways of infection into the intracranial space in this area would probably not go through those perforations of the cribriform plate per se but through the subarachnoid spaces around the olfactory nerves, which are in close communication with the intracranial space as pointed out by Pratt (1925).
Both sides of the cribriform plate are covered with very thick connective tissues that effectively seal the bony perforations, resist penetration of injuries, and readily repair any damage if it occurs.
Chances of intracranial infection in this area would be greater when a group of olfactory nerves are injured at a higher level.

4. The antero-lateral aspect of the roof of the ethmoid cells. Observations of the roof of the ethmoid cells by the transillumination method demonstrated frequent rarefaction of the bony roof at the antero-lateral aspect of the roof of the ethmoid cells as shown in Figure 7.
Further observation of the area often revealed small perforations of the bony plate as shown in Figure 8.
The structure of the dura mater in the area has been found to be quite different from those in other areas, that is, the connective tissues of the dura mater are closely and densely adherent with the irregular surface of the bony plate.

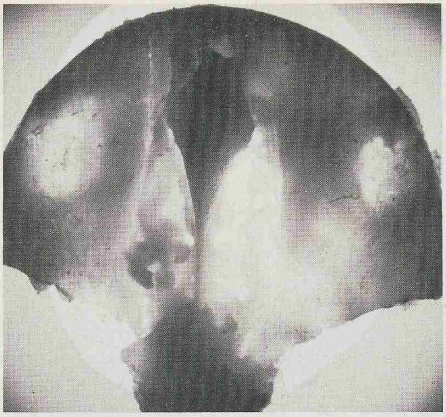

Figure 7. Rarefaction of the bone at the antero-lateral aspect of the roof of the ethmoid sinus as shown by the transillumination method.

Figure 8. Two small bone defects at the antero-lateral aspect of the roof of the ethmoid sinus. (a view from above)

Separation of the dura mater from the bony roof, accordingly, was much more difficult here than it was in other areas. The effective local defense system against invasion of infections into the intracranial space at the roof of the sinuses appeared to be complemented by the close interweaving of the bony structure and the connective tissues of the dura mater.

Injuries to the roof of the ethmoid sinus in this area however, would be considerably different from the injuries in other areas where the bony walls could be separated from the dura mater without causing severe damages to the dura mater. Any injury to the bony roof in such areas would be no less than injuries to the dura mater itself and may induce intracranial invasion of infections far readily than in other areas.

Rarefaction of the bony plate at the antero-lateral aspect of the roof of the ethmoid cells was seen in 5 out of 34 sinuses or in 14% of the sinuses studied.

5. The area about the posterior ethmoid nerve.

The bony roof of the paranasal sinuses gradually increases its thickness toward the posterior aspect of the anterior cranial fossa or the sphenoid sinus.

Therefore, the roof of the posterior ethmoid cells is seldom injured during surgery. The only area of the roof of the cells where the bony roof is not as thick as other areas is its medial aspect where the posterior ethmoid nerve penetrates the bony roof.

Figures 9 and 10 show such findings with several dehiscences around the pathway of the posterior ethmoid nerve. Among the 34 sinuses examined, 9 sinuses or 26%

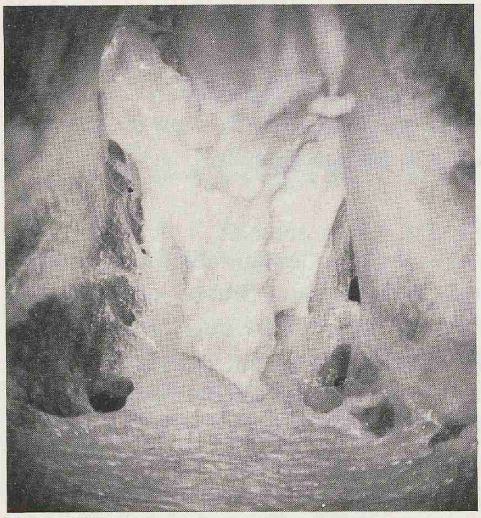

Figure 9. Several bone dehiscences or defects near the posterior ethmoid nerve foramen on both sides. (a view from above)

Figure 10. Several bone dehiscences about the posterior ethmoid nerve foramen. (a view from below)

showed such rarefaction of the bony roof around the nerve foramen, while the bony defects were seen in 5 sinuses or in 14% in the area.

CONCLUSION

Useful information for macroscopic and microscopic surgery of the paranasal sinuses was obtained through this operating microscopic study of the roof of the ethmoid cells.

The roof of the bony sinus has been found not to be a simple plate of bone of even thickness but a structure of varying thickness with uneven surfaces and frequent dehiscences and defects.

The author has found five different areas where the bony structures are considered most vulnerable to injury during surgery of the ethmoid cells. The five areas, most of them located at the medial side of the ethmoid cells, are characterized by a very thin bony plate with frequent bony dehiscences and defects.

The adhesions of the dura mater to the bony structure in some areas are so tight that a separation of the bony plate, in many instances, would inevitably damage the integrity of the dura mater and may result in leakage of cerebrospinal fluid.

Although the roof of the paranasal sinuses has been proved to be a wall of highly effective defense against the invasion of infections into the intracranial space, the integrity of the defense system may presumably be preserved by the combining of

such structures as the dura mater, the bony plate, and the sinus mucosa. The surgeon needs to keep in mind the anatomy of the roof of the paranasal sinuses as indicated by predecessors (Mosher, 1929; Takahashi, 1971) and the location of the above five dangerous areas when he untertakes any procedure in the ethmoid cells either macroscopically or microscopically.

RÉSUMÉ

La sinusectomie endonasale est l'une des opérations les plus utiles pour le traitement de la sinusite chronique. Une étude antérieure que l'auteur a effectuée sur l'incidence de complications de la sinusectomie a révélé que, sur un total de 450.000 opérations du sinus accomplies au Japon, il survient, dans 0,15% des cas, des lésions de la base du crâne, et dans 0,01% des cas, une méningite aiguë.

Dans la présente étude, une observation minutieuse de 17 prélèvements du crâne (34 côtés), effectuée au microscope d'opération, a révélé cinq importants endroits dangereux dans le plafond du sinus ethmoïde, où les structures anatomiques présentent une vulnérabilité inusuelle à des lésions pendant les opérations; ceci à cause de crevasses et de défauts osseux.

L'auteur a trouvé de fréquentes crevasses osseuses, où du tissu conjonctif submuqueux était en contact direct avec la dure-mère, ainsi que des structures inusuelles de fortes adhérences, entre l'os et le tissu conjonctif de la dure-mère.

L'accent est mis sur la nécessité d'exécuter l'opération du sinus ethmoïde avec le plus grand soin; on souligne que la chirurgie microscopique est un moyen utile pour une chirurgie méticuleuse et pour la prévention de petites lésions.

REFERENCES

1. Halle, M., 1927: Klinisch Wichtiges von normalen Bau des Siebbeins und selten Anomalitaten. Zeitschr. fur H. N. u O Bd. 18, 504–515.
2. Mosher, H. P., 1929: The surgical anatomy of the ethmoidal labyrinth. Ann. Oto. Rhino. Laryng. 38, 869–901.
3. Ohnishi, T., 1977: Injury to the base of the skull during nasal surgery. Oto-rhino-laryng. Tokyo 20, 11–26.
4. Pratt, J. A., 1925: The present status of the intranasal ethmoid operation, Arch. Otolaryng. 1, 42–50.
5. Takahashi, R., 1971: Clinicoanatomical structures of the canalis orbitocranialis and canalis orbitoethmoidalis in relation to the ethmoid cells. A collection of Ear, Nose and Throat Studies, pp. 174–191, Medical library, Jikei Univ. School of Med., Minato-ku, Tokyo.
6. Takahashi, R., 1971: Endonasal operation of chronic Ethmoiditis. A collection of Ear, Nose and Throat Studies, pp. 372–389, Medical library, Jikei Univ. School of Med., Minato-ku, Tokyo.

Toshio Ohnishi, M.D.
Department of Otolaryngology St. Luke's International Hospital
10-1 Akashi-cho, Chuo-ku, Tokyo, Japan