REVIEW

Rhinology, 43, 82-85, 2005

Surgery of the frontal recess and frontal sinus*

Peter-John Wormald

Department of Surgery - Otolaryngology Head and Neck Surgery, University of Adelaide, South Australia

SUMMARY

Surgery on the frontal recess and frontal sinus remains a challenge for endoscopic sinus surgeons. This paper examines the philosophy behind such surgery and presents a technqiue for 3-dimensional reconstruction of the anatomy of the frontal recess and frontal sinus. Utilizing this anatomical reconstruction the surgeon is encouraged to develop a pre-operative step-by-step surgical plan for each cell identified within the frontal recess and frontal sinus and thereby predict the anatomy of this region before surgery is undertaken. An increased understanding of the anatomy of this region should improve the surgeon's surgical confidence and ability to remove all the obstructing cells from the frontal sinus ostium.

Key words: frontal sinus, frontal recess, endoscopic sinus surgery, frontal sinus anatomy.

PHILOSOPHY OF SURGERY IN THE FRONTAL SINUS AND FRONTAL RECESS

Surgery in the frontal recess is considered challenging as it is unforgiving of poorly performed or incomplete surgery. Incomplete removal of cells in the frontal recess is one of the commonest causes of failure of endoscopic sinus surgery (ESS)[1-3]. There are three distinct philosophies for surgical management of chronic rhinosinusitis affecting the frontal sinus and frontal recess. Minimal Invasive Sinus Technique or MIST includes an uncinectomy without opening of the maxillary sinus and opening of the bulla ethmoidalis [4-6]. The authors state that clearance of disease in the ostio-meatal complex will result in resolution of disease in the frontal sinus and frontal recess [4-6]. However, there are few studies supporting this theory and the published studies all come from the same group of investigators [4-6]. While their results appear to be comparable with standard ESS techniques [6], these investigators did not randomize their patients between MIST and standard ESS and did not show that groups undergoing MIST had equivalent radiological burden of disease as those undergoing ESS. Until such studies are published, the value of MIST for the treatment of medically resistant disease of the frontal sinus and frontal recess remains unproven. The second philosophy is symptom dependent and states that the frontal recess should only be surgically addressed if the patient has symptoms relating to the frontal sinus i.e. frontal pain and/or pressure. When patients have both frontal sinus symptoms and disease on the CT scan there is probably little debate that surgery should be performed [7]. The third philosophy is contentious in that if the frontal sinus, a frontal recess cell/s or outflow pathway is diseased after adequate medical treatment, it should be cleared irrespective of the presence or absence of frontal sinus pain or pressure [7,8]. This may seem aggressive but partial removal of cells in the frontal recess is more likely to result in stenosis and obstruction of the outflow tract of the frontal sinus than complete removal of the cells, thereby producing an all or nothing philosophy [7,8]. The spaces around the cells in the frontal sinus and in the outflow pathway are very narrow and partial removal of a cell wall is likely to create damage to apposing mucosal surfaces, leading to fibrosis and obstruction [2,7,8]. In addition if significant disease is left in the frontal sinus and frontal recess, this disease may continue to cause ongoing symptoms not specifically referrable to the frontal sinus such as rhinorrhea, post-nasal drip and nasal obstruction and the patient may feel that the surgery was a failure. For these reasons I have adopted this philosophy in my approach to frontal sinus disease.

UNDERSTANDING THE ANATOMY OF THE FRONTAL SINUS AND FRONTAL RECESS

The frontal recess and frontal sinus remain the most challenging region of sinus surgery due to the variability and very complex nature of the cellular patterns seen in this region [9]. Therefore surgery in this region is thought to often result in iatrogenic stenosis or obstruction of the frontal outflow tract. However with new developments in imaging particularly with the arrival of the high definition spiral multi-slice CT scanners, we now have the ability to image the frontal recess in the axial plane with excellent reconstructions in the coronal and parasagittal planes. The box of data generated by the multislice scanner produces reconstructions that are indistinguishable from images taken primarily in the coronal plane. Evaluation of the frontal recess in the coronal, parasagittal and axial planes results in the surgeon generating a better understanding

*Received for publication: April 28, 2005; accepted: April 29, 2005

of how the cells are placed and significantly affects the surgical plan that the surgeon makes to address these cells [10]. Classifying the different cells that occur in the frontal recess allows the common configurations to be understood and facilitates communication and comparison of surgical techniques. The most user friendly classification is that proposed by Kuhn11. Table 1 [10].

Table 1. Modified Kuhn Classification [11] of frontal ethmoidal cells.

Agger nasi cell
Supraorbital ethmoid cells
Fronto-ethmoidal Cells
• Type 1 Single frontal recess cell above agger nasi cell
• Type 2 Tier of cells in frontal recess above agger nasi cell
• Type 3 Single massive cell pneumatizing cephalad into frontal sinus
• Type 4 (modified from original classification A cell pneumatizing through into the frontal sinus and extending > 50% of the vertical height of the frontal sinus [7,8])
Frontal bulla cells
Supra bulla cells
Interfrontal sinus septal cell (or intersinus septal cell)

The agger nasi cell is the first cell seen on in the coronal scan anterior to the insertion of the middle turbinate and is present in more than 90% of patients [12]. This cell forms the key to understanding the anatomy of the frontal recess as it can be easily identified on the CT scan and in the patient during surgery [13]. The term 'fronto-ethmoidal cell' is given to an anterior ethmoidal cell that is associated with the frontal process of the maxilla (the so called "beak" of the frontal sinus). This differentiates these cells from cells associated with the bulla ethmoidalis, the supra bulla cells. If a supra- bulla cell migrates along the skull base into the frontal sinus, it is termed a frontal bulla cell indicating its origin from the region of the bulla ethmoidalis. Finally the cell associated with the intersinus septum of the frontal sinus is termed the interfrontale sinus septal cell or the intersinus septal cell.

In order to generate a 3-dimensional picture of the cellular construction of the frontal recess, each cell is identified first on the coronal CT scan and then on the parasagittal scan [13,14] (Figure 1). In this example the first cell seen is the Kuhn type 3 (K3) cell followed by the agger nasi cell and the bulla ethmoidalis and intersinus septal cell.

If each sequential cell that is seen on the coronal scan is correlated to the parasagittal scan, a 3 dimensional picture of the cell structure can be built. To simplify this further a building block is used to illustrate each cell [13,14]. As the agger nasi cell can be easily identified in both the coronal scan and the parasagittal scan (cell number 2) a building block is placed representing this cell. For each additional cell seen a further building block is placed adjacent to the agger nasi block depending upon its location. In this example there is a K3 cell on the right side pneumatizing through the frontal ostium into the frontal sinus (cell number 1). In addition a small intersinus septal cell is seen (cell number 4). Each additional cell that is seen on the sequential coronal scans should be identified on the parasagittal scan. This confirmatory process of locating the cell first on the coronal scan then confirming its size and position on the parasagittal scan, allows the building blocks to be developed (Figure 1).

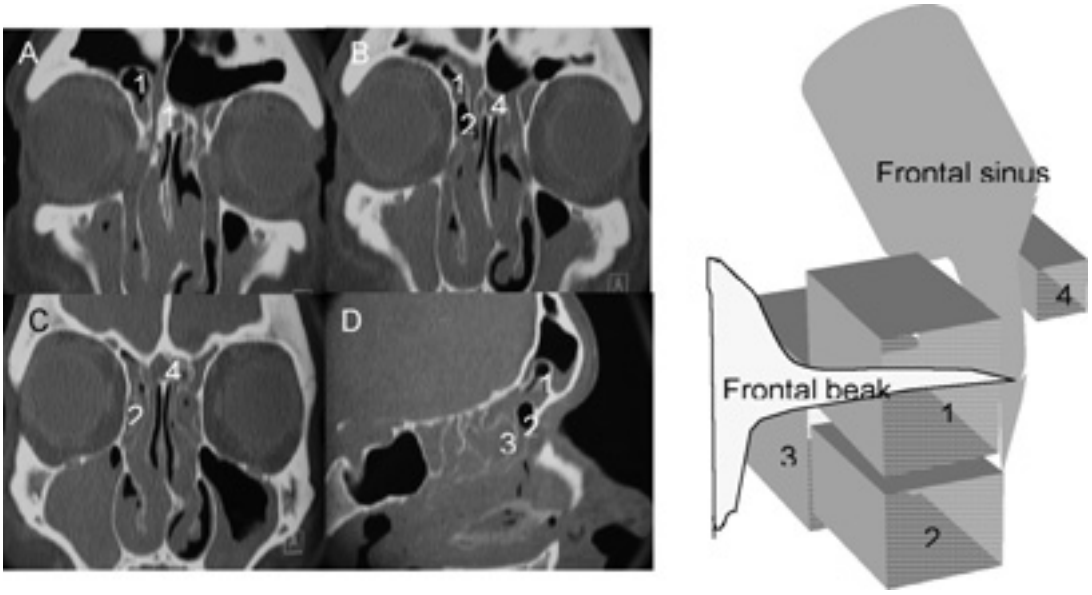

Figure 1. CT scans A, B and C are sequential coronal CT scans. Scan D is a right sided parasagittal scan and therefore the right side is assessed. Cell number 1 (K3 as it protrudes into the frontal sinus) is seen on the coronal scan and identified on the parasagittal scan. Cell number 2 (agger nasi cell) and cell number 3 (bulla ethmoidalis) are also identified in both coronal and parasagittal scans. Cell number 4 (intersinus septal cell) is seen on the coronal but not the parasagittal as the parasagittal cut is lateral to the cell.

A building block is placed for each cell numbered on the coronal and parasagittal scans. This creates a 3-dimensional picture of the anatomy of the frontal recess.

Once a complete picture of the cellular anatomy is developed the drainage pathway of the frontal sinus needs to be determined

THE DRAINAGE PATHWAY OF THE FRONTAL SINUS

While it is important to understand the cellular structure of the frontal recess, it is vital to determine the drainage pathway of the frontal sinus [13,14]. During the dissection of the frontal recess the probes and curettes are placed along this drainage pathway and the cell/s are fractured and removed [10,11,13,14]. Curettes or probes should not be placed through the roof of a cell as this may lead to damage to the skull base if the surgeon has made an error and has confused the roof of the cell and the skull base. This situation can be avoided by passing the curette or probe along the drainage pathway. The probe or curette should slide along the pathway with minimal pressure. As soon as force is required the surgeon should reassess the anatomy as it is likely that the probe is not in the drainage pathway and forcing the probe may result in a complication. The best scans to assess the drainage pathway of the frontal sinus are the axial scans [14]. Start well above the frontal ostium in the frontal sinus and then follow the frontal sinus and its drainage pathway inferiorly. The previously identified cells are located in the frontal recess and their position confirmed by referring to the coronal and parasagittal scans. The frontal sinus drainage pathway is then plotted through these cells into the frontal recess. This pathway is also checked on the coronal and parasagittal scans to confirm its course (Figure 2).

SURGICAL PRINCIPLES

The first step is to expose the anterior wall of the agger nasi cell by elevating an axillary flap [7,8]. The anterior wall is removed and the agger nasi cell is identified. The posterior wall and roof of the agger nasi cell are removed and the adjacent cell/s identified. The probe or curette is placed along the frontal sinus drainage pathway and each cell is consecutively removed [7,8,14]. This is done in a deliberate pre-planned manner. The philosophy is to try to predict the anatomy and to create a surgical plan for each cell before performing the surgery. The operative plan for the right side of Figures 1 and 2 would be to open the anterior wall of the agger nasi cell using the axillary flap technique and then to place the curette posteromedial to the cell and remove its medial and posterior walls and the its roof. This would open the K 3 cell and its lumen should be identified. The next and probably most important step is to identify the frontal drainage pathway. Remembering the 3-dimensional reconstruction we should be able to identify it medial to the K3 cell. A curette or probe is slid up this pathway and the K3 cell removed by fracturing it laterally and anteriorly. The cell remnants are removed and the frontal ostium visualized. Once the ostium is clearly visualized, the intersinus septal cell's (4) medial wall can be removed to further clear the frontal ostium. If there is uncertainty regarding the drainage pathway, a frontal sinus mini-trephine may be placed and the frontal sinus irrigated with Fluorescein-stained saline [7,8]. The frontal sinus drainage pathway can then be followed by following the Fluorescein-stained saline into the frontal sinus.

CONCLUSIONS

Surgery in the frontal recess should only be performed if the surgeon has a clear understanding of the cellular structure and the drainage pathway of the frontal recess. Such an understanding comes with the ability to read the CT scans in all three planes and to reconstruct a 3–dimensional picture of the anatomy. A clear understanding of the common cellular variations of the frontal recess and frontal sinus is needed so that each individual frontal recess can be assessed with these patterns in mind and a clear surgical plan can be developed and put into action. The surgeon should try to predict the anatomy before operating on the frontal recess and if the pre-operative assessment proven to be incorrect at surgery, the anatomical reconstruction should be reviewed and any errors identified. Regular repetition of this technique should improve the surgeon's ability to read and 3-dimensionally reconstruct the cellular structure and drainage pathway of the frontal sinus and frontal recess and improve the surgical outcome.

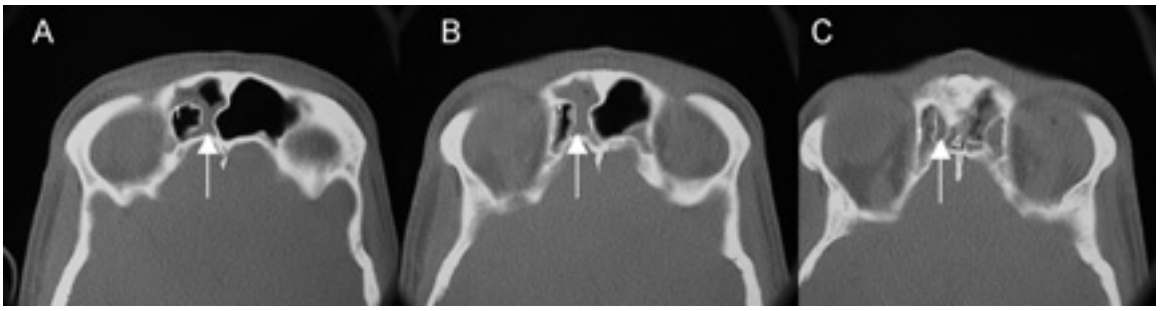

Figure 2. Axial scans start above the frontal recess (scan A) and move progressively inferiorly (scans B and C). The K3 cell (1) is seen on the right side with the frontal sinus pathway medial to it (white arrow). Note the appearance of the intersinus septal cell (4) in axial scan C with the drainage pathway between it and the K3 cell. e parasagittal cut is lateral to the cell.

REFERENCES

1. Kennedy DW, Senior BA (1997) Endoscopic Sinus Surgery - A Review. Otolaryngol Clin Nor Am 30: 313-330.
2. Thawley SE, Deddens AE (1995) Transfrontal Endoscopic Management of Frontal Recess Disease. Am J Rhinol 9: 307-311.
3. Ramadan HH (1999) Surgical causes of failure in endoscopic sinus surgery. Laryngoscope 109: 27-29.
4. Setcliffe RC III (1996) Minimally Invasive Sinus Surgery: Rationale and Technique. Otolaryngol Clin N Am 29: 115-129.
5. Catalano PJ, Setcliffe RC III, Catalano LA (2001) Minimally invasive sinus surgery in the geriatric patient. Operative Techn Otolaryngol Head Neck Surg 12: 85-90.
6. Catalano PJ, Roffman E (2003) Outcome of patients with chronic sinusitis after minimally invasive sinus technique. Am J Rhinol 17: 17-22.
7. Wormald PJ (2002) The axillary flap approach to the frontal recess. Laryngoscope 112: 494-499.
8. Wormald PJ, Chan SZX (2003) Surgical Techniques For The Removal of Frontal Recess Cells Obstructing The Frontal Ostium. Am J Rhinol 17: 221-226.
9. Stammberger H, Kennedy D, Bolger W, et al. (1995) Paranasal sinuses: Anatomic terminology and nomenclature. Ann Otol Rhinol Laryngol 104 (suppl 167): 7-16.
10. Kew J, Rees G, Close D, Sdralis T, Sebben, R, Wormald PJ. (2002) Multiplanar reconstructed CT images improves depiction and understanding of the anatomy of the frontal sinus and recess. Am J Rhinol 16: 119-123.
11. Kuhn FA (1996) Chronic frontal sinusitis: the endoscopic frontal recess approach. Operative techniques Otolaryngol Head Neck Surg 7: 222-229.
12. Bolger WE, Butzin CA, Parsons DS (1991) Paranasal sinus bony anatomic variations and mucosal abnormalities: CT analysis for endoscopic sinus surgery. Laryngoscope 101: 56-64.
13. Wormald PJ (2003) The Agger Nasi Cell. The key to understanding the anatomy of the frontal recess. Otolaryngol Head Neck Surg 129: 497-507.
14. Wormald PJ (2005) The anatomy of the frontal recess and frontal sinus with 3-D reconstruction. Chp 6 In Endoscopic sinus surgery; anatomy, 3-D reconstruction and surgery published by Thieme Inc (New York).

Professor P-J Wormald
Dept. of Surgery - Otolaryngology, Head and Neck Surgery
Adelaide and Flinders Universities
The Queen Elizabeth Hospital
28 Woodville Road, Woodville
South Australia 5011
Australia

Tel: +618-8222-7158
Fax: +618-8222-7419
E-mail: peterj.wormald@adelaide.edu.au