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Ultrastructural ciliary changes of maxillary sinus mucosa following functional endoscopic sinus surgery: an image analysis quantitative study

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Abstract

This was a study of the effect of functional endoscopic sinus surgery (FESS) on the ciliary regeneration of maxillary sinus mucosa in patients with chronic maxillary sinusitis, using objective quantitative methods. Twenty specimens from the mucosa of both the superolateral wall and the ostium of the maxillary sinus were sampled during FESS and then six to 12 months later. They were light examined first by light microscopy and then by scanning electron microscopy in combination with image analysis software in order to study the cilia under higher magnification and to calculate proportion of the field that was ciliated. Samples were taken and studied at Cairo University hospital. This study showed that the maxillary sinus mucosa in chronic sinusitis is capable of regeneration and could return towards normal with the improvement of ventilation and drainage of the maxillary sinus following FESS. There were no significant changes in the degree of glandular hyperplasia, goblet cells or pathological glands after surgery.

Key words: Maxillary sinus; Sinusitis; Ultrastructure, cilia; Microscopy, electron, scanning

Introduction

The concept of functional endoscopic sinus surgery (FESS) in the region of the osteomeatal complex as a treatment modality for chronic sinusitis was based on the outstanding research work of Messerklinger in the 1950s and 1960s. His theory states that improving the drainage in the critical area of the osteomeatal complex by infundibulotomy, ethmoidectomy, middle meatal antrostomy with, or without, clearance of the frontal recess area, often restores normal physiological functions to all sinuses, with restoration of normal mucociliary clearance, enabling pathological sinus mucosa to revert to its normal condition after FESS. Many authors have since that time tried to evaluate and to prove the validity of this theory through symptomatic, radiological and pathological evaluation pre- and post-operatively.[1,2]

The aim of this work was to study the regeneration potential of the maxillary sinus cilia following improvement of ventilation and drainage by FESS. Scanning electron microscopy was used to scan and examine the cilia, then image analysis software techniques were used to calculate quantitatively the proportion of the field that was ciliated. Lastly the results were compared before and after the operation to check the validity of FESS and Messerklinger's theory by showing if FESS is associated with ciliary regeneration.

Materials and methods

Materials

Twenty adult patients with chronic maxillary sinusitis were enrolled in this study. Chronic sinusitis in our patients was defined as inflammation of the nasal and paranasal mucosa, with persistent mucoid or mucopurulent discharge for longer than three months, that was resistant to repeated antimicrobial therapy and antral irrigation.[3] Nine patients were men and 11 were females, with ages ranging from 17 to 53 years (mean 35). The patients were diagnosed as having chronic sinusitis from their medical history, physical examination, and the results of endoscopic examination and computed tomography (CT) scanning. Cases of allergic rhinitis were not included in this study.

FESS was performed in all patients under general anaesthesia, using the technique described by Stammberger and Hawke.[4] In 12 out of 20 cases (60 per cent) septal surgery was performed as an integral part of the FESS procedure, to correct septal deflections and to facilitate access to the osteomeatal complex region.

For the electron microscopy studies, the biopsies were taken from two sites: (a) the maxillary sinus superolateral wall and (b) the maxillary sinus ostium. The biopsies were taken from the maxillary sinus

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superolateral wall only for light microscopy. Macroscopically, the maxillary sinus mucosa looked very variable and there was no consistent gross picture; in some cases the mucosa looked hyperplastic or even polypoidal and in others the mucosa was very thin and atrophic. Sometimes mucoid or even purulent exudate was present on the surface of the mucosa but cultures were not taken from it. The biopsies were taken at the time of the operation (perioperative) to study the condition of the mucosa in chronic sinusitis before surgical intervention, and then after a follow-up period of six to 12 months (mean 8.1 months) to assess the regeneration of the cilia after FESS. The biopsies were taken using fine-tipped cutting forceps through the surgically created large maxillary sinus ostium, and the follow-up biopsies were taken under local anaesthesia. Extreme care was taken not to traumatize the specimen so as not to crush the cilia, and all the patients had a follow-up CT scan at the time of the follow-up biopsy.

Histopathological examination

In order to study the effect of chronic sinusitis on the maxillary sinus mucous membrane, and the role of the FESS in reverting these histopathological effects, the method described by Forsgren *et al.*, 1993, 1995, 1998[5,6,7] was followed, in which all the specimens taken perioperatively and after the follow-up period were examined histopathologically by a single senior pathologist, who was unaware of which of the biopsies were perioperative and which were follow-up biopsies. Semiquantitative grading was done in comparison with normal mucosal histology (0 (normal), 1 + (mild changes), 2 + (moderate changes), 3 + (moderately severe changes), 4 + (severe changes)). The following parameters were assessed: polypoid formation, squamous cell differentiation, surface ulceration, the number of goblet cells, subepithelial thickening of the basement membrane, inflammatory cells, oedema, fibrosis, submucosal glands hyperplasia, pathological glands and the degree of vascular engorgement. The perioperative findings were statistically compared to the follow-up findings, to show if FESS was associated with significant changes in the pathological parameters or not.

Scanning electron microscopy

Samples were washed in saline to remove the surface mucus. Preparations for scanning electron microscopy then included: prefixation with one per cent glutaraldehyde and sodium cacodylate 0.3, sequential dehydration in graded ethanol (50, 70, 80, 90, 95 and 100 per cent), substitution with isoamyl acetate, critical point drying with carbon dioxide and sputter coating with gold. All specimens were observed using a scanning electron microscope (JSM-T200, JEOL Ltd-Tokyo, Japan) at 5000 magnification.

Measurement of ciliary area

The term ciliary area designates the area that is occupied by cilia on the surface of the epithelium.

TABLE I
HISTOPATHOLOGICAL CHANGES IN MAXILLARY SINUS MUCOSA BEFORE AND AFTER FESS IN OUR STUDY

Semiquantitative histological grading (0/1+/2+/3+/4+)	Pre-operative (n = 20)	Post-operative (n = 20)
Polypoid formation	3/3/11/3/0*	0/20/0/0/0**
Goblet cell	15/2/0/3/0	14/6/0/0/0
Squamous cell differentiation	20/0/0/0/0	20/0/0/0/0
Ulceration	0/9/11/0/0	14/3/3/0/0
Basement membrane thickening	6/3/6/3/2	3/11/3/3/0
Oedema	3/12/2/3/0	11/9/0/0/0
Submucosal glands hyperplasia	5/6/9/0/0	6/3/11/0/0
Pathological glands***	17/3/0/0/0	17/3/0/0/0
Vascular congestion	3/3/11/3/0	9/11/0/0/0
Fibrosis	8/6/6/0/0	2/12/6/0/0
Inflammatory cells	0/9/6/5/0	6/9/5/0/0

*These figures indicate that pre-operatively out of our 20 patients; 3 showed grade 0 polypoidal changes (normal), 3 showed grade 1 polypoidal changes (mild), 11 showed grade 2 polypoidal changes (moderate), 3 showed grade 3 polypoidal changes (moderately severe) and 0 showed grade 4 polypoidal changes.
**While after the operation, all the 20 patients were classified by the pathologists with regard to the polypoidal changes as grade 1 and no patient was classified as grade 0, 2, 3 or 4.
***Hyperplastic changes with focal dysplastic or focal metaplastic changes.

The software image analysis programme (AQUITUS 1A) was utilized to calculate automatically the ciliary area using the following steps: capturing the image, image processing (selecting a region, add mask, thresholding, make binary and choose and select measurements) and analyzing the data by the analysis programme.

Statistical analysis

The significance of changes in the ciliary area during and after the operation was evaluated by the Wilcoxon signed rank test. The same test was used to compare the difference of the ciliary area between the maxillary ostium and the superolateral wall. A p value of less than 0.05 was considered significant. The values were stated within the study as the mean $\pm$ SD.

The Chi-square test was used to evaluate the significance of changes in the light microscopic images pre- and post-FESS, again p values of less than 0.05 were considered significant.

Results

Histopathological study

The distribution and semiquantitative grading of the histopathological parameters in the perioperative and the follow-up specimens are shown in Table I.[1]

FESS produced the following statistical changes in the pathological parameters studied:

(1) Polypoidal formation: There was a significant decrease in the degree of polypoidal formation (p = 1.255 e-06<0.001).
(2) Goblet cells number: FESS produced a non-significant change in the goblet cells' population (p = 0.0807>0.05).

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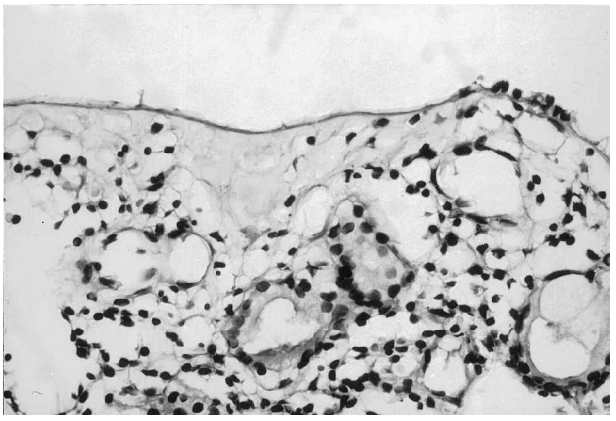


FIG. 1
Light microscopic view of the maxillary sinus mucosa before surgery showing surface ulceration (H&E; ×100).

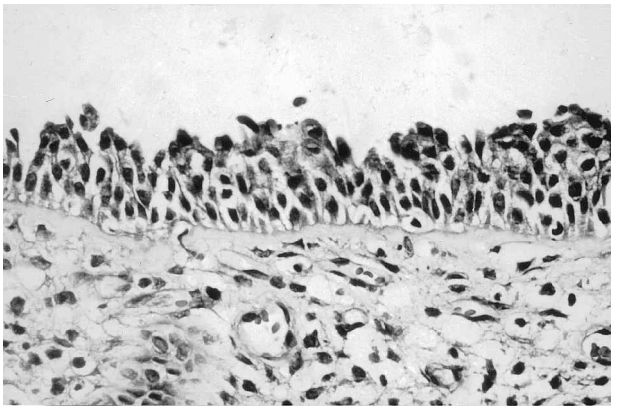


FIG. 2
Post-operative view from the same patient eight months after surgery showing surface mucosal regeneration (H&E; ×100).

(3) Ulceration: (Figures 1 and 2); FESS produced a significant decrease in the degree of surface ulceration (p = 2.069 e-05<0.001).
(4) Basement membrane thickening: FESS produced a non-significant change in the degree of basement membrane thickening (p = 0.0729>0.05).
(5) Oedema: FESS produced a significant decrease in the degree of oedema (p = 0.0186<0.05).
(6) Submucosal gland hyperplasia: FESS produced a non-significant change in the degree of submucosal gland hyperplasia (p = 0.5244>0.05).
(7) Vascular engorgement: FESS produced a significant decrease in the degree of vascular engorgement in the submucosa (p = 7.964 e-05<0.001).
(8) Fibrosis: FESS produced a non-significant change in the degree of fibrosis (p = 0.0608>0.05).
(9) Inflammatory cells: FESS produced a significant reduction in the degree of inflammatory cell infiltration in the submucosa (p = 0.0112<0.05).
(10) There was a non-significant change in the distribution of the pathological glands (p = 1.000>0.05).
(11) There were no cases of squamous cell differentiation in this study, so it was not evaluated statistically.

Results of studying the ciliary area of the maxillary sinus

The ciliary area of the maxillary sinus mucosa was sampled during surgery (perioperative). In the superlateral wall (biopsy A), the ciliary area ranged from 0.14 per cent to 28.7 per cent. The mean of the ciliary area was 10.12 per cent with a standard deviation of 6.62. In the maxillary sinus ostium (biopsy B) the ciliary area ranged from 0.28 per cent to 29.34 per cent, with a mean of 11.11 per cent and a standard deviation of 9.40.

The following results could be extracted from the previous perioperative data: The results from the ciliary area showed moderate variation between the maxillary sinuses, and this was true for both the superolateral wall and the ostial region. The results from the ciliary area in the perioperative specimens were significantly lower than the normal values for both the superolateral wall and the ostium (the normal values of the ciliary area in non-pathological maxillary sinuses ranged between 91–98 per cent at the superolateral wall, and between 47–53 per cent at the ostial region). There were no significant differences between the values of the ciliary area at the superolateral wall and at the ostial region perioperatively, (p = 0.715>0.05).

The ciliary area of the maxillary sinus mucosa was sampled after a mean period of 8.1 months post-operatively (follow-up biopsies). In the superolateral wall (biopsy A), the ciliary area ranged from 17.50 to 91.37 per cent with a mean of 50.72 per cent and a standard deviation of ± 24.97. In the maxillary sinus ostium (biopsy B), the ciliary area ranged from 32.74 to 64.6 per cent, with a mean of 51.91 per cent and a standard deviation of ± 11.31.

The following results could be extracted from the previous data:
(1) There was no significant difference in the ciliary area values between the superolateral wall and the ostial region in the follow-up specimens, (p = 0.853>0.05).
(2) The values of the ciliary area at both the superolateral wall and the ostial region in the follow-up biopsies showed significant increase over those in the perioperative biopsies, (p = 0.00<0.05 for both sites) (Figures 3–7).
(3) The variation between the sinuses was more marked and the standard deviation values were higher in the follow-up specimens than in the perioperative specimens, this was particularly true in the superolateral wall specimens.
(4) Although we were mainly concerned in our ultrastructural study by the cilia from a quantitative point of view, it was possible to describe many ultrastructural defects in the cilia in patients with chronic sinusitis such as ciliary knobs, ciliary disorientation, epithelial metaplasia and compound cilia (Figures 8 and 9).

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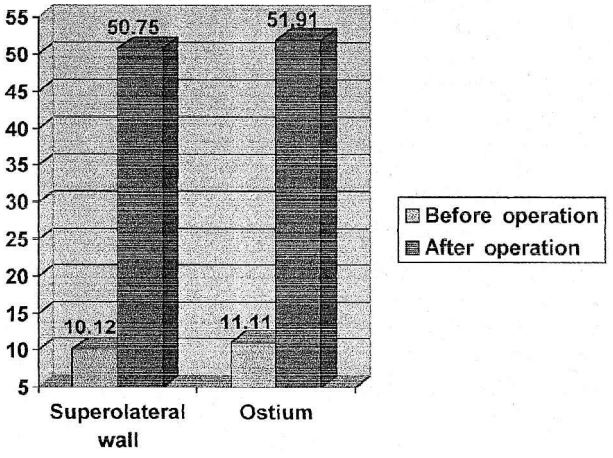


FIG. 3
The improvement of the ciliary area after FESS.

Discussion

Although it has been reported in many studies in the literature that FESS normalized maxillary sinus mucosa macroscopically, based on both endoscopic examination and CT evaluation,[1,2] and although several authors have studied the effect of endonasal sinus surgery on the structure and the ultrastructure of the sinuses from the qualitative point of view,[5] the effect of FESS on the ciliated epithelium of the maxillary sinus has rarely been reported quantitatively in the available literature.[9]

In the present study, chronic sinusitis has been found to be associated with marked ciliary loss in the mucosa of the maxillary sinus, and FESS increased the density of the cilia significantly both in the superolateral wall of the maxillary sinus, and in the maxillary sinus ostial region 8.1 months after surgery.

To study the number, density and the regeneration potential of the cilia, the parameter of ciliary area was used. This term designates the area occupied by the cilia on the surface of epithelium, and was previously used by Yin *et al.*, and Guo *et al.*, in their quantitative study on the cilia of the ear and paranasal sinuses respectively.[8,9]

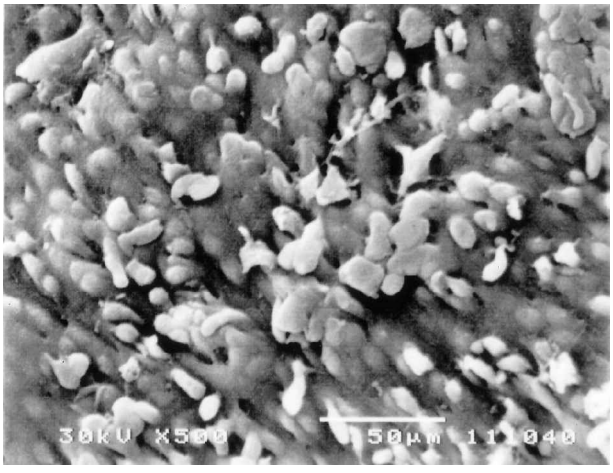


FIG. 4
Scanning electron microscopic view taken pre-operatively showing extensive ciliary destruction with short abnormal discrete cilia (×500).



FIG. 5
Scanning electron microscopic view of the same patient nine months post-operatively showing ciliary regeneration (×5000).

The ciliary area was calculated by scanning electron microscopy, which is a fascinating technique for studying the surface of relatively large areas of the mucosa (up to 1 cm^2), and then software image analysis was used to scan the images and calculate the ciliary area.

The results of the light microscopic examination of the specimens showed:

(1) a significant decrease in vascularity, polypoid formation and ulceration in the follow-up biopsies after FESS compared to the perioperative biopsies.
(2) a significant decrease in submucosal inflammatory cells, and significant decrease in submucosal oedema in the follow-up biopsies when compared to the perioperative biopsies.
(3) non-significant changes in the degree of glandular hyperplasia, fibrosis, goblet cells, pathological glands and basement membrane thickening.

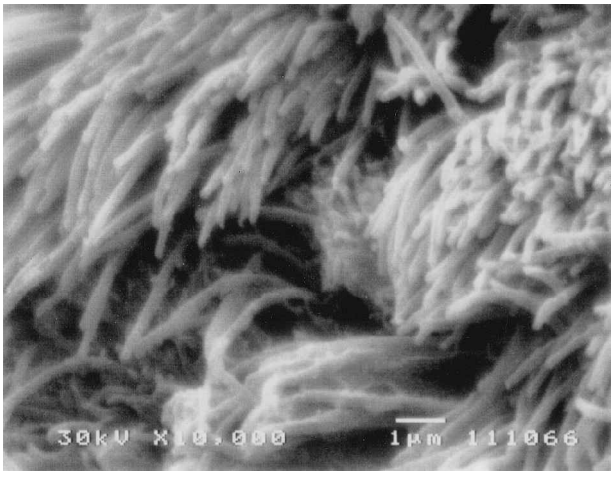


FIG. 6
Scanning electron microscopic image taken pre-operatively showing ciliary destruction in the centre of the field with the remaining cilia matted together (×10 000).

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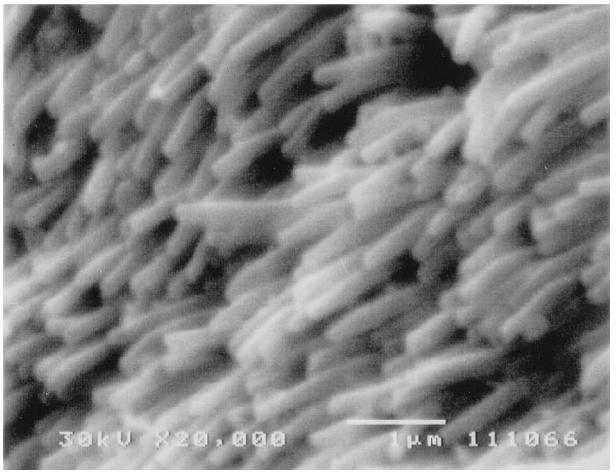


FIG. 7

Scanning electron microscopic image taken post-operatively under very high magnification (×20 000) with complete regeneration of the cilia, all beating in one direction.

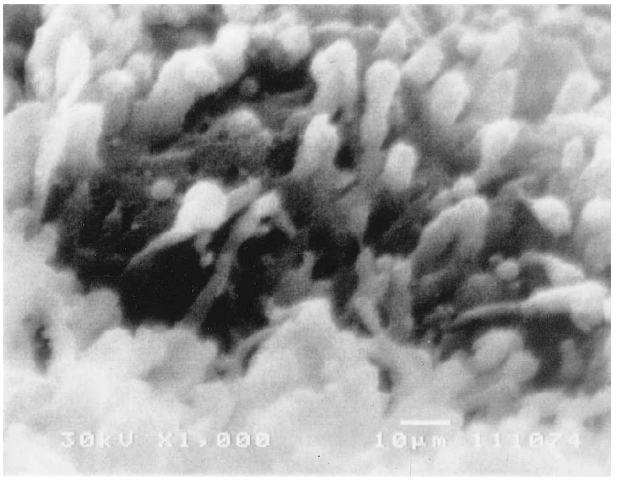


FIG. 9

Pre-operative scanning electron microscopic image showing ciliary knobs on the top of the cilia (×1000).

These results partially agree with the work of Forsgren *et al.*, which was conducted on 55 patients with a follow-up period of one year.[5] They found a statistically significant decrease in the inflammatory cells and degree of oedema and a statistically significant increase in the fibrosis, while they did not find any statistically significant changes in the goblet cell population, subepithelial thickening, squamous cell differentiation, polypoidal formation, submucosal gland hyperplasia or pathological glands.

The difference between our results and Forsgren *et al.*'s,[5] work is that we found statistically significant changes in vascularity, polypoidal formation and in the degree of ulceration while Forsgren *et al.*, did not achieve such results.[5] Our results could be explained on the basis of the fact that FESS is supposed to decrease the inflammatory process in the sinus mucosa with all of its pathological parameters.

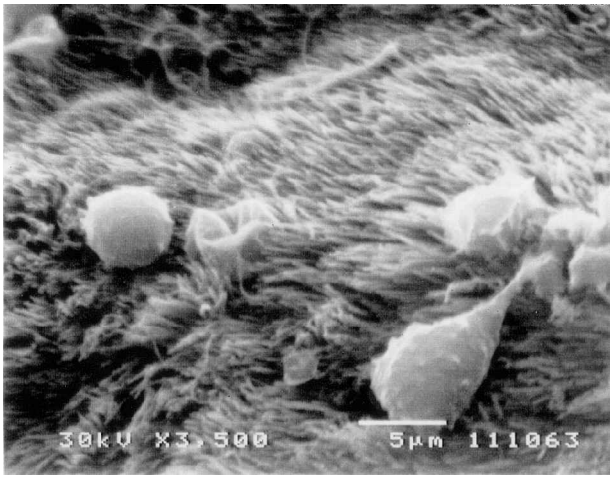


FIG. 8

Post-operative scanning electron microscopic view showing the maxillary sinus cilia pushing mucus drops on top of the cilia (×3500).

Forsgren *et al.*,[5] also found a statistically significant increase in the degree of fibrosis, while the present study did not achieve such a result. In FESS the mucosa of the maxillary sinus itself is not touched so the degree of fibrosis is not supposed to increase after the operation.

Both our study and that of Forsgren *et al.*, did not find significant changes in the degree of basement membrane thickening. This is a logical finding, as the FESS entails no direct touching of the sinus mucosa.[5]

We also like Forsgren *et al.*,[5] could not reach a statistically significant change in the goblet cell population, submucosal gland hyperplasia and pathological glands. This could be explained by the fact that these changes are rarely seen in a single specimen, so to reach significant changes a larger pool of cases is needed.

In the present study, the perioperative values of the ciliary area at the superolateral wall and the ostium of the maxillary sinus were 10.12 per cent and 11.11 per cent respectively. Review of the available literature showed that quantitative study of the ciliary area of the maxillary sinus mucosa has rarely been reported in normal persons or in patients with chronic sinusitis. Halma *et al.*, showed the distribution of ciliated cells in the normal human nose and paranasal sinus mucosa. They reported that in all parts of the maxillary sinus the density of the cilia was very high, ranging from 91.3 to 97.7 per cent except at the ostial region where the density dropped nearly by half and was approximately 47 per cent.[10]

The present quantitative study clearly showed that the ciliary area of the maxillary sinus decreased in chronic maxillary sinusitis compared to normal sinuses, and this decrease was evident both in the superolateral wall and in the maxillary sinus ostial region. The percentage of area that had cilia in the superolateral wall was 10.16 per cent compared to a normal value of 91.3–97.7 per cent, and the ciliary area in the ostial region was 11.11 per cent compared to a normal value of 47 per cent in this region.

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The decrease in the ciliary area may be due to destruction of the cilia by the chronic inflammatory process, increase of squamous metaplasia, microvillous cells and goblet cells.

Our results are similar to those obtained in a study conducted by Guo *et al.*,[9] on a total number of 17 patients with a mean follow-up period of 7.6 months, they also reported significant reduction in the ciliary area in patients with chronic sinusitis compared to normal values, and reported an average ciliary area of 60.7 per cent with a standard deviation of ± 28.8 in the superolateral wall, and an average ciliary area of 39.9 per cent with a standard deviation of ± 21.5 in the maxillary sinus ostium.

In contrast to the study done by Guo *et al.*,[9] we did not find any significant difference in the percentage of ciliated area perioperatively between the superolateral wall and the ostial region (10.12 and 11.11 per cent) respectively with p value = 0.715>0.05 (non-significant). In the study conducted by Guo *et al.*,[9] the difference between the perioperative values of the ciliary area at the superolateral wall (60.7 per cent) and the ostial region (39.9 per cent) was very highly significant.

In our study there was mild variation in the ciliary area results perioperatively in both the superolateral wall and the ostial region. In the superolateral wall the lowest ciliary area value was 0.14 per cent and the highest ciliary area value was 28.71 per cent with a standard deviation of ± 6.92, while in the ostial region the lowest ciliary area value was 0.28 per cent and the highest ciliary area value was 29.34 per cent, with a standard deviation of ± 9.46. This contrasted to the study done by Guo *et al.*,[9] where there was more marked variation in the results of the ciliary area. In their study in the superolateral wall the lowest ciliary area value was 2.9 per cent and the highest was 95 per cent, with a standard deviation of ± 28.8, while in the maxillary sinus ostium the lowest ciliary area value was 2.7 per cent and the highest value was 74 per cent with a standard deviation of ± 21.5.

In our study the ciliary area of the maxillary sinus mucosa increased after a mean follow-up period of 8.1 months following FESS in the superolateral wall from an average value of 10.1 per cent to an average value of 50.7 per cent. There is a very highly significant difference between the pre-operative and the post-operative values of the ciliary area (p = 0.00<0.05). This agrees with the results of Guo *et al.*,[9] where there was also a significant increase in the ciliary area of the superolateral wall after a mean period of 7.6 months after FESS from an average of 60.7 per cent to an average of 74.3 per cent.

The ciliary area also increased in the maxillary sinus ostial region after FESS from an average of 11.1 per cent to an average of 51.9 per cent. There is a very highly significant difference between the perioperative and the follow-up value of the ciliary area at the maxillary sinus ostial region (p = 0.00<0.05). This also agrees with the results of Guo *et al.*,[9] where there was also a significant increase in the ciliary area of the maxillary sinus ostial region from an average of 39.9 per cent perioperatively, to an average of 51.3 per cent after the follow-up period.

These post-operative values suggest that FESS increases the density of the cilia significantly both in the superolateral wall and the maxillary sinus ostial region 8.1 months after the surgery, and that FESS is associated with ciliary regeneration. But although the number of the cilia increases significantly after the surgery, this does not mean that the cilia were functioning normally. The normal physiological activity of the regenerated cilia still needs further studies in the future.

The following conclusions could be extracted from the careful study of our follow-up results of the proportion of the field that was ciliated and comparing it to the results published by Guo and his colleagues:

(1) The results of the proportion of the field that was ciliated in the follow-up biopsies at the maxillary sinus ostium were, in our study, an average of 51.9 per cent. This means that FESS raised the proportion of the field that was ciliated in this region to around normal values, this matches well with the results of Guo *et al.*,[9] who reported a value of 51.3 per cent in the follow-up biopsies at the maxillary sinus ostium.

(2) The results of the proportion of the field that was ciliated in the follow-up specimens at the superolateral wall of the maxillary sinus were in our work an average of 50.7 per cent. This if compared to normal values of the maxillary sinus superolateral wall in Halma *et al.*'s,[10] work, which ranged between 93–97 per cent means that FESS although it increased the density of cilia inside the maxillary sinus after a mean period of 8.1 months, the cilia did not regenerate completely. These findings coincide with the results of Guo *et al.*,[9] in 1997 who found the same observations although the values of the proportions of the field that were ciliated inside the maxillary sinus after the follow-up period in this work were significantly higher than that in our work. (74.3 per cent compared to 50.7 per cent). This observation probably means that a longer period of follow-up than that used in both our work and in Guo *et al.*'s, 1997 work is essential for complete regeneration of the cilia, and also throws light on the fact that regeneration of the cilia is complete in the region of the osteomeatal complex before the maxillary sinus itself.

Conclusion

FESS is considered nowadays as the main treatment modality of chronic sinusitis after failure of medical treatment. FESS was based on Messerklinger's theory which was the result of the outstanding research work conducted by W. Messerklinger in the 1950s and the 1960s, on the pathways of

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secretion transport of the sinuses. This theory states that improving the drainage in the critical area of the ostomeatal complex by uncinectomy, ethmoidectomy, middle meatal antrostomy, with or without clearance of the frontal recess area often restores normal physiological functions to all sinuses, with restoration of normal mucociliary clearance, enabling mucosa to return to its normal condition after the FESS.

Since that time FESS has replaced the more radical operations such as the Caldwell Luc operation and the less physiological operations such as inferior antrostomies.

The idea of our study was to prove and confirm the validity of FESS in the treatment of chronic sinusitis. In the published literature this was always done by evaluation of patients' symptoms using subjective scores, taking pre-operative and then post-operative CT scans or by studying the effect of FESS on the structure and the ultrastructure of the sinus mucosa. However proving the success of FESS should be directed towards proving the validity of the Messerklinger's theory through two ways, firstly by proving that clearing the osteomeatal complex region is associated with ciliary regeneration and increase in the number of cilia in the sinuses, and secondly by providing that these regenerating cilia area functioning well.

The second point has been well discussed in many articles in the literature, and the parameters of mucociliary clearance and ciliary beat frequency have been studied in details before and after FESS.

The problem was always in proving the first point, and the difficult part was that it was not easy at all to count the cilia before and then after FESS to prove that FESS is associated with an increase in the number of cilia, as cilia cannot be evaluated numerically in cut section i.e. under light microscopy and transmission electron microscopy, because the area studied in these sections and the number of cilia is so small.

Scanning electron microscopy was used to study the surface of relatively large areas of the surface of the mucosa (up to 1 cm^2 could be studied under low magnification) and then computer software programmes (Aquitus 1) were used to sweep the images and calculate the ciliary area, which is the area on the surface of the mucosa covered by cilia. By that way we could obtain figures that were compared statistically before and then after FESS to reach solid objective data.

By proving that the number and the function of the cilia have improved after FESS the success of the operation and the validity of the Messerklinger's theory could be confirmed.

In this study we reached the following conclusions: chronic maxillary sinusitis was associated with definite ciliary destruction. FESS was associated with a statistically significant increase in the ciliary area at both the superolateral wall and the ostium and the maxillary sinus ostium. In the maxillary sinus the cilia regenerated to normal density, while at the maxillary sinus superolateral wall the density did not reach normal values.

References

1 Lawson W. The intranasal ethmoidectomy: An experience with 1077 procedures. *Laryngoscope* 1991;**101**:367–73

2 Levine HL. Functional endoscopic sinus surgery: evaluation, surgery and follow up of 250 patients. *Laryngoscope* 1990;**100**:79–88

3 Melen I, Lindhal L, Andreasson L. Chronic maxillary sinusitis. *Acta Otolaryngol (Stockh)* 1986;**101**:320–7

4 Stammberger H, Hawke M. *Essentials of Functional Endoscopic Sinus Surgery*. Missouri, USA: Mosby Year Book Inc, 1993

5 Forsgren K, Kumlien J, Stierna P, Carlsoo B. Regeneration of maxillary sinus mucosa following surgical removal; experimental study in rabbits. *Ann Otol Rhinol Laryngol* 1993;**102**:459–66

6 Forsgren K, Fukami M, Kumlien J, Penltila M, Stierna P. Endoscopic and Caldwell-Luc approaches in chronic maxillary sinusitis: A comparative histopathological study on preoperative and postoperative mucosal morphology. *Ann Otol Rhinol Laryngol* 1995;**104**:350–7

7 Forsgren K, Westrin KM, Fukami M, Stierna P. Effect of surgery on mucosal pathologic changes following experimental sinusitis in rabbits. *Ann Otol Rhinol Laryngol* 1998;**107**:155–63

8 Jin CS, Majima Y, Hamaguchi Y, Takeuchi K, Sakakura Y. A quantitative study of the ciliary area of experimental otitis media with effusion in cats. *Acta Otolaryngol (Stockh)* 1991;**438**(suppl):5–10

9 Guo Y, Majima Y, Hattori M, Seki S, Sakakura Y. Effect of functional endoscopic sinus surgery on maxillary sinus mucosa. *Arch Otolaryngol* 1997;**123**:1097–100

10 Halma AR, Decrelon S, Bijloos JM, Clement PAR. Density of epithelial cells in normal human nose and the paranasal sinus mucosa; A scanning electron microscopic study. *Rhinology* 1990;**28**:25–32

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