

Extensive versus functional endoscopic sinus surgery for chronic rhinosinusitis with nasal polyps and asthma: A 1-year study

Feng-Hong Chen, M.D.,¹ Jie Deng, M.D.,¹ Hai-Yu Hong, M.D.,² Rui Xu, M.D., Ph.D.,¹ Jie-Bo Guo, M.D.,¹ Wei-Jian Hou, M.D.,¹ Yue-Qi Sun, M.D., Ph.D.,¹ Yin-Yan Lai, M.D., Ph.D.,¹ Hua-Bin Li, M.D., Ph.D.,³ and Jian-Bo Shi, M.D., Ph.D.¹

ABSTRACT

Background: Functional endoscopic sinus surgery (FESS) is considered to be the standard procedure for chronic rhinosinusitis with nasal polyps (CRSwNP). However, for CRSwNP that accompanies asthma, the results are not satisfying. Extensive endoscopic sinus surgery (EESS) aimed at reducing the inflammatory load has been indicated as a viable option for refractory chronic rhinosinusitis.

Objective: To evaluate the clinical outcomes and safety of EEES (middle turbinate and superior turbinate resection and total ethmoidectomy) for patients with CRSwNP and with asthma.

Methods: This was a prospective, single-institute cohort study conducted in a tertiary teaching hospital. Patients with CRSwNP and with asthma who were proceeding to surgery were enrolled. There were 23 patients in the EEES group and 24 patients in the FESS group. The preoperative disease severity was evaluated by the visual analog scale (VAS), Lund-Kennedy (L-K) endoscopy score, computed tomography Lund-Mackay score, asthma control test (ACT), and pulmonary function test. Clinical outcomes were comparatively evaluated between the two groups after a 1-year follow-up by using the VAS score, the postoperative endoscopic score (E score), L-K score, ACT score, and pulmonary function test.

Results: The disease severity (general VAS score, endoscopic L-K score, computed tomography score, ACT score) showed no significant differences between the two groups before surgery ($p > 0.05$). One year after surgery, both groups achieved significant improvement in the VAS score and endoscopic L-K score. The EEES group showed better improvement in the olfactory VAS score and E score compared with the FESS group (mean [standard deviation] change of olfactory VAS, 6.00 ± 3.67 versus 3.30 ± 3.44 , $p = 0.015$; mean [standard deviation] E score, 0.31 ± 0.18 versus 0.66 ± 0.26 , $p < 0.001$). No significant differences were found in the change of general nasal symptom VAS score, other individual VAS scores (nasal congestion, discharge, headache and/or facial pain), L-K score, ACT score, and pulmonary function between the two groups ($p > 0.05$).

Conclusion: EEES for patients with CRSwNP and with asthma may help to improve the subjective olfaction and endoscopic appearance.

(Am J Rhinol Allergy 30, 143–148, 2016; doi: 10.2500/ajra.2016.30.4271)

Chronic rhinosinusitis (CRS) is one of the most common diseases in China, with an estimated prevalence of 8% in the general population, which affected 107 million persons.¹ Based on the presence or absence of nasal polyps (NP), CRS is commonly subdivided into two types: CRS with NP (CRSwNP) and CRS without NP.² In East Asia, an estimated 10–23% of patients with CRSwNP have asthma, and this subgroup may represent a more severe form of CRSwNP.^{3,4} Results of studies show that patients with CRSwNP and asthma tend to have poor outcomes after functional endoscopic sinus surgery (FESS) and a higher recurrence rate.^{5,6} In our previous study, only 24% of patients with CRS and asthma achieved a well-controlled

level of CRS and 25% underwent revision sinus surgery 3 years after FESS.⁷

Extensive endoscopic sinus surgery (EESS) or radical sinus surgery was performed for refractory CRS and had better outcomes than FESS.^{8–10} However, it is unclear whether EEES improves outcomes in patients with CRSwNP and asthma. Therefore, we decided to perform EEES in CRSwNP patients with asthma, and compared the outcomes with the patients who underwent FESS in our previous study. Our hypothesis was that the performance of EEES, which involved complete removal of NP with partial middle turbinate (MT) and superior turbinate (ST) resection and total ethmoidectomy but sparing unaffected mucosa, could improve surgery outcomes.

METHODS

IRB approval was obtained from the First Affiliated Hospital of Sun Yat-Sen University, and all the patients provided informed consent before enrollment. Level of evidence is 2c.

Subjects

EES Group. Consecutive patients with CRSwNP and asthma in whom medical treatment failed and who were proceeding to surgery were allocated to undergo EEES in Otorhinolaryngology Hospital, the First Affiliated Hospital of Sun Yat-sen University, from May 2011 to September 2013.

FESS Group. We retrospectively analyzed the prospectively collected data from these consecutive patients with CRSwNP and asthma for whom medical treatment failed and who underwent FESS between September 2006 and May 2011 in the same hospital and by the same surgeon. Some of these data were published in 2014.⁷

From the ¹Allergy and Cancer Center, Otorhinolaryngology Hospital, The First Affiliated Hospital of Sun Yat-sen University, Guangzhou, China, ²Department of Otolaryngology, Head and Neck Surgery, The Fifth Affiliated Hospital of Sun Yat-sen University, Zhuhai, China, and ³Department of Otolaryngology, Head and Neck Surgery, Xinhua Hospital, Shanghai Jiaotong University School of Medicine, Shanghai, China

This study was supported by grants from Industry Foundation of the Ministry of Health, China (201202005), Guangdong Province Technology Projects (2013B021800112) and Natural Science Foundation of Guangdong Province (2014A030313106)

F.-H. Chen and J. Deng contributed equally to this article

The authors have no conflicts of interest to declare pertaining to this article

Address correspondence to Jian-Bo Shi, M.D., Otorhinolaryngology Hospital, the First Affiliated Hospital, Sun Yat-Sen University, 58 Zhongshan Road II, Guangzhou, Guangdong, P. R. China 510080

E-mail address: shijb@mail.sysu.edu.cn

Address correspondence to Hua-Bin Li, M.D., Department of Otolaryngology, Head and Neck Surgery, Xinhua Hospital, Shanghai Jiaotong University School of Medicine, No. 1665, Kongjiang Road, Shanghai, P. R. China 200092

E-mail address: allerygli@163.com

Copyright © 2016, OceanSide Publications, Inc., U.S.A.

Eligibility and Exclusion Criteria

Diagnosis Criteria. CRS was defined according to the European Position Paper on Rhinosinusitis and Nasal Polyps.² Asthma was diagnosed by the Global Initiative for Asthma¹¹. Allergies were confirmed by a UniCap system (Thermo Fisher Scientific, Uppsala, Sweden).

Inclusion Criteria. Inclusion criteria were patients with concomitant CRSwNP with asthma, all the patients had adequate medical treatment for CRS for at least 3 months without a satisfactory result, CRS general visual analog scale (VAS) score of >5, olfactory score of >5, Lund-Kennedy NP score of >2, and ≥18 years old.

Exclusion Criteria. Exclusion criteria were patients who underwent endoscopic sinus surgery (ESS) before with MT and/or ST resection, ethmoidectomy, acetylsalicylic acid (ASA) intolerance, immunodeficiency, cystic fibrosis, bronchiectasis, chronic obstructive pulmonary disease, diabetes mellitus, neoplasia, fungal rhinosinusitis, pregnant or lactating, upper airway infection in 1 month, or asthma in acute exacerbation.

Treatment

All the surgeries were performed by the same senior rhinology specialist (J.-B. Shi) with the patients under general anesthesia. The surgery extent was based on the extent of the CT and intraoperative judgment.

EES. The procedure started with a delicate polypectomy. A partial MT resection was the second step. The inferior two-thirds of MT was resected by an endoscopic turbinate scissor, just spared the superior, sagittal-oriented portion as a landmark for the skull base and a small stump posteriorly in the region of the sphenopalatine foramen. The inferior two-thirds of the ST was then resected as the third step. At the fourth step, a total ethmoidectomy was performed, which removed all the bony lamellae and mucosa within the labyrinth. Antrostomies of maxillary, frontal, and sphenoid sinuses were then performed with meticulous operation to preserve the mucosa around the ostium. Mucosa in the sinuses was left intact. Only irreversible lesions, *e.g.*, polyps, and severe polypoid change mucosa were removed.

FESS. The procedure was performed by using Messerklinger technique as described.⁷

Medical Treatment

All the patients in both groups took prednisolone 30 mg, once a day for 7 days before surgery. Expandable sponges (Medtronic-XOMED; Merocel, Jacksonville, FL) were packed for 24 to ~48 hours and then extracted. All the patients were then started on budesonide nasal spray (Rhinocort Aqua; AstraZeneca, Sodertälje, Sweden) 128 µg twice a day and normal saline solution nasal lavage. This nasal spray was continuously used for at least 3 months. If the patient achieved good control,² then all medications were stopped. If patients didn't achieve well control, and budesonide nasal spray would keep being used. Antihistamine was not routinely used for each patient unless he or she was diagnosed with allergic rhinitis, and the symptoms of allergic rhinitis were not controlled by steroid nasal spray alone.

Outcome Measures

To avoid potential bias, a second otorhinolaryngology specialist (F.-H. Chen) independently assessed the outcomes. For subjective measures, the symptoms were scored on a visual analog score (VAS) from 0 to 10 cm, with 0 cm being "not troublesome" and 10 cm being "the most thinkably troublesome." Five VAS scores concerning the following symptoms were noted: general nasal symptom, nasal congestion, nasal discharge, olfactory reduction and/or loss, and facial pain and/or headache.

For objective assessment, endoscopic results were scored with the systems proposed by the Lund-Kennedy (L-K) score¹² and the postoperative endoscopic score (E score).¹³ The E score was applied for the

postoperative ESS examination. The endoscopic appearance of the operated sinuses and olfactory clefts (OC) was scored as follows: 0, normal condition; 1, sinus only partially observable due to occupation by polyps, edematous mucosa, and/or discharge; 2, unobservable due to complete occupation by polyps and/or discharge. The percentage of the total score to the maximum possible score for operated sinuses was rated as the E score. A CT of paranasal sinuses was performed before the surgery in all the patients and was scored by the Lund-Mackay system.¹⁴

Asthma was evaluated by the asthma control test (ACT) and pulmonary function test.¹⁵ Pulmonary function tests, including percentage forced expiratory volume in 1 second (FEV₁%), percentage peak expiratory flow, forced vital capacity (FVC), and FEV₁ forced expiratory volume in 1 second (FEV₁) to FVC ratio were measured before surgery by using a spirometer (Sensor Medics Inc. 2100, Yorba Linda, CA) that met American Thoracic Society standards. A FEV₁% of <80% was graded as abnormal.

Complications

We observed the complications of frontal recess stenosis, atrophic rhinitis, empty-nose syndrome, and cerebrospinal fluid leak and nasal bleeding during surgery and 1 year after surgery.

Sample Size

A sample size of 20 patients was calculated for each group, with 80% power and a value of 0.5 by using the formula: $n = ([Z_{\alpha/2} + Z_{\beta}]^2 \times [2(\sigma)^2]) / (\mu_1 - \mu_2)$.¹⁶

Statistical Analyses

Statistical analysis was performed with SPSS 16.0 for Windows (SPSS Inc., Chicago, IL). Values were expressed as means (standard deviations [SD]) for continuous variables and as numbers and percentages for categorical variables. Baseline factors, including demographics, medical comorbidities, and measurement of disease severity (CT, endoscopy, VAS) were compared between the groups by using the Mann-Whitney *U* test, independent *t*-test, and the χ^2 test when appropriate. A comparison between preoperation and postoperation was assessed by using the Wilcoxon signed rank test or the paired *t*-test when appropriate. A comparison of improvement between the groups was assessed by comparing changes of scores (preoperative minus postoperative) with regard to endoscopy, VAS, and ACT by using the unpaired *t*-test or Mann-Whitney *U* test when appropriate. The level of significance was 0.5.

RESULTS

Demographics

There were 23 patients in the EESS group and 24 patient in the FESS group. Three patients (13%) in the EESS group and two patients (8.3%) in the FESS group were lost to follow-up. The demographic data of both groups are summarized in Table 1. There were no statistically significant differences in sex, age, allergy, smoke, previous sinus surgery, course of CRS, CT score, and pulmonary function.

Baseline Disease Burden

There were no significant differences in baseline characteristics, including VAS score, L-K score, ACT score, and pulmonary function indexes (percentage peak expiratory flow, FEV₁/FVC), except the mean (SD) VAS score of olfactory reduction and/or loss was worse in the EESS group than in the FESS group (9.89 ± 0.27 versus 8.27 ± 2.58 ; $p = 0.001$) and the mean (SD) FEV₁% was worse in the EESS group (99.31 ± 17.79 versus 84.94 ± 19.01 ; $p = 0.039$). (Table 1).

Table 1 Demographics and preoperative disease burden in the EESS and FESS groups

Parameter	EESS Group (n = 20)	FESS Group (n = 22)	p*
Mean (SD) age, y	42.65 ± 8.86	48.82 ± 11.15	0.056
No. men/women	13/7	10/12	0.204
Allergy, no. (%)	10 (50.0)	10 (45.4)	0.557
Smoker, no. (%)	4 (20.0)	1 (4.5)	0.122
Previous sinus surgery, no. (%)	5 (25.0)	5 (22.7)	0.863
CRS, mean (SD)			
Course, y	7.55 ± 6.73	7.08 ± 5.89	0.875
VAS score			
General	7.79 ± 1.70	7.93 ± 0.95	0.505#
Congestion	6.53 ± 3.36	7.25 ± 2.08	0.405
Discharge	6.65 ± 3.34	6.75 ± 2.32	0.909
Olfaction	9.89 ± 0.27	8.27 ± 2.58	0.008#
Head and/or facial pain	2.53 ± 2.95	1.64 ± 2.57	0.306#
L-K score	9.76 ± 1.86	9.86 ± 1.49	0.790#
ACT score	17.81 ± 4.59	17.42 ± 2.99	0.763
Asthma			
ACT, mean (SD)	23.47 ± 2.27	22.27 ± 2.33	0.104
Lung function, abnormal, no. (%)	2 (10.0)	7 (31.6)	0.085
FEV ₁ , % predicted, mean (SD)	99.31 ± 17.79	84.94 ± 19.01	0.039
PEF, % predicted, mean (SD)	90.82 ± 36.14	83.21 ± 17.73	0.480
FEV ₁ :FVC, mean (SD)	79.81 ± 7.91	73.82 ± 9.99	0.090

EESS = extensive endoscopic sinus surgery; FESS = functional endoscopic sinus surgery; SD = standard deviation; CRS = chronic rhinosinusitis; VAS = visual analog scale; L-K = Lund-Kennedy endoscopic score; ACT = asthma control test; FEV₁ = forced expiratory volume in 1 second; PEF = peak expiratory flow; FVC = forced vital capacity.

*Data was presented as mean ± SD for continuous variables and n (%) for categorical variables. Independent t test was used for continuous data comparison. χ^2 test was used for all frequency comparisons except # the Mann-Whitney U test was used.

Outcomes of CRS and Impact on Asthma 1 Year After Surgery

One year after surgery, all of the VAS scores and endoscopic L-K scores were remarkably improved in both groups. There were no differences with the ACT scores and pulmonary function indexes (FEV₁%, percentage peak expiratory flow, FEV₁:FVC) in the two groups (Table 2). None of the patients underwent revision surgery during 12 months of follow-up.

Comparison of Change between the 2 Groups

When comparing changes between the groups, the mean (SD) olfaction VAS score of the EESS group improved more significantly than did the FESS group (6.00 ± 3.67 versus 3.30 ± 3.44; $p = 0.015$). There were no differences in other VAS scores. (Fig. 1).

For endoscopic improvement, mean (SD) L-K scores showed no significant difference (7.00 ± 2.64 [EESS group] versus 5.80 ± 3.58 [FESS group]; $p = .341$). Conversely, mean (SD) E scores showed that the EESS group had a better endoscopic outcome (0.31 ± 0.18 [EESS group] versus 0.66 ± 0.26 [FESS group]; $p < .001$), although there was a weak positive correlation between the E score and the L-K score. (Figs. 2 and 3) There were no significant differences of change in ACT scores and pulmonary function indexes ($p > 0.05$) (Table 2).

Complications

No major complications were observed in both groups during surgery and at the 1-year follow-up period. Frontal recess stenosis was found in one case of FESS group but not in the EESS group. Two early cases in the EESS group had postoperative hemorrhage during the first 24 hours. The bleeding site was at the MT stump near the sphenopalatine foramen. Electrocoagulation was used under endoscopy to stop the bleeding. Afterward, the MT stump was routinely coagulated during surgery, and no more postoperative hemorrhage occurred. There was no postoperative hemorrhage in the FESS group. No atrophic rhinitis, empty-nose syndrome, or cerebrospinal fluid leak was found in either group during follow-up.

DISCUSSION

Our study included two groups of patients with CRSwNP and asthma, with equal preoperative disease burden based on clinical,

Table 2 Improvement of CRS and asthma for the EESS and FESS groups 1 year after surgery*

Outcome	EESS Group, mean (SD) (n = 20)	p ₁ #	FESS, mean (SD) (n = 22)	p ₂ #	p ₃ ¶
CRS					
VAS score					
General	5.42 ± 2.43	0.001§	5.25 ± 2.25	0.000§	0.822
Congestion	5.53 ± 4.20	0.000	5.02 ± 2.88	0.000	0.686
Discharge	5.25 ± 3.67	0.000	5.09 ± 2.90	0.000	0.885
Olfaction	6.00 ± 3.67	0.001§	3.30 ± 3.44	0.001§	0.015
Head and/or facial pain	2.75 ± 3.17	0.005§	1.45 ± 2.26	0.007§	0.114
L-K score	7.00 ± 2.64	0.003§	5.80 ± 3.58	0.000§	0.341
E score	0.31 ± 0.18		0.66 ± 0.26		<0.001
Asthma					
ACT	-0.477 ± 2.17	0.395§	-1.77 ± -0.07	0.114§	0.611
FEV ₁ , % predicted	-14.00 ± 26.34	0.462	-2.13 ± 12.41	0.620	0.302
PEF, % predicted	-3.3 ± 3.05	0.199	-5.13 ± 20.83	0.539	0.889
FEV ₁ :FVC	-5.88 ± 14.45	0.554	2.81 ± 8.53	0.351	0.221

CRS = chronic rhinosinusitis; EESS = extensive endoscopic sinus surgery; FESS = functional endoscopic sinus surgery; SD = standard deviation; VAS = visual analog scale; L-K = Lund-Kennedy endoscopic score; E = postoperative endoscopic score; ACT = asthma control test; FEV₁ = forced expiratory volume in 1 second; PEF = peak expiratory flow; FVC = forced vital capacity.

*Improvement is defined as the preoperative score minus the postoperative score, except the E score is a postoperative score.

#The p₁ and p₂ values represent pre- and postoperative comparisons, respectively, within the group by the paired t-test, §except the Wilcoxon signed rank test.

¶The p₃ value represents a comparison of improvement between the two groups by using the unpaired t-test, ||except the Mann-Whitney rank test.

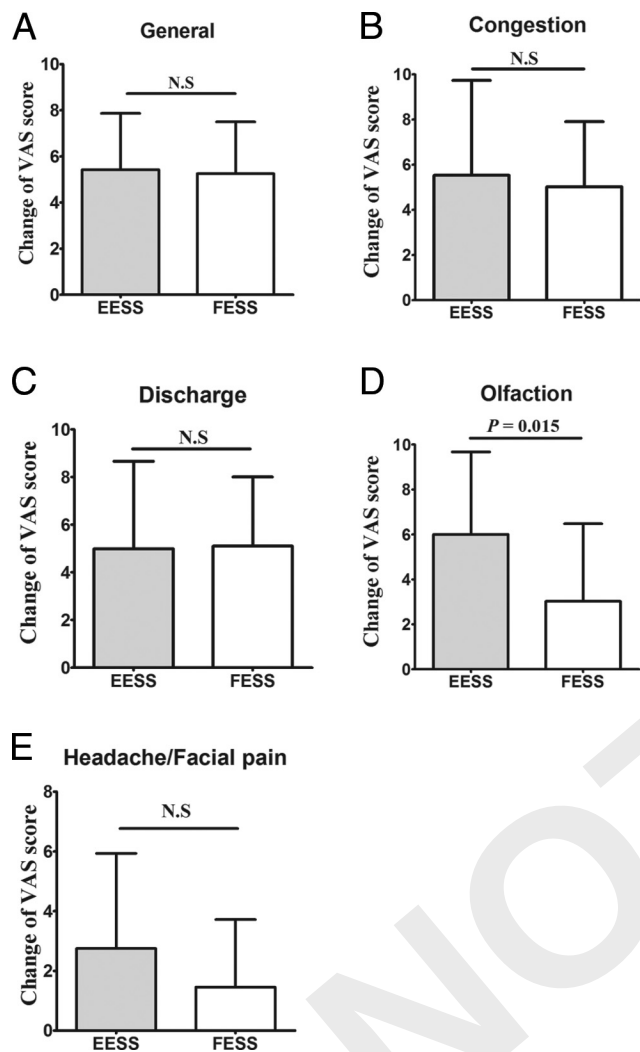


Figure 1. Visual analogue scale (VAS) scores and Lund-Kennedy score improvement in the extensive endoscopic sinus surgery (EES) group compared with the functional endoscopic sinus surgery (FESS) group. (A) General nasal symptom. (B) Congestion. (C) Discharge. (D) Olfaction. (E) Headache/facial pain.

radiologic, and endoscopic parameters, who underwent EESS or FESS. The outcomes showed that both procedures impacted significantly all nasal symptoms and the endoscopic score at the 1-year follow-up. Furthermore, the EESS group led to more statistically significant improvement in olfactory perception and the postoperative endoscopic E score compared with the FESS group. To our knowledge, this is the first study that compared the outcomes of EESS and FESS in concomitant patients with CRSwNP and asthma.

Whether or not to perform an MT resection during ESS for CRSwNP is still under debate. Although some surgeons are concerned that MT resection may impair olfactory nerve fibers and result in anosmia, analysis of our data found that, even with a worse olfactory VAS score at baseline, the EESS group gained more notable benefit in subjective olfactory function. Meanwhile, Havas and Lowinger¹⁷ and Soler *et al.*¹⁸ reviewed the olfaction outcome after MT resection. They used the smell test to assess olfaction, and their patients included both those with CRS without NP and those with CRSwNP, with and without asthma. Their results revealed that MT resection improved olfaction. For EESS, such as nasalization, some researchers reported olfaction increased and remained at a steady level in a long-time follow-up.^{19,20}

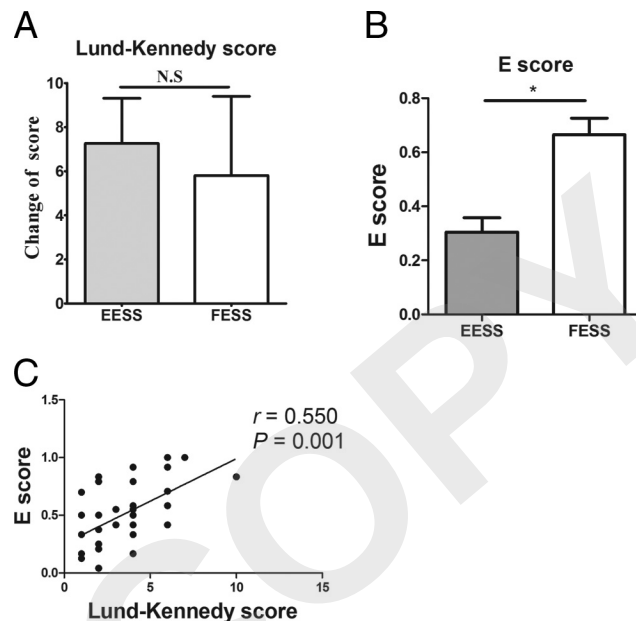


Figure 2. Endoscopic scores of the extensive endoscopic sinus surgery (EES) group compared with the functional endoscopic sinus surgery (FESS) group. (A) Change of Lund-Kennedy score. (B) Postoperative endoscopic score (E score). (C) Correlation of postoperative Lund-Kennedy score and E score.

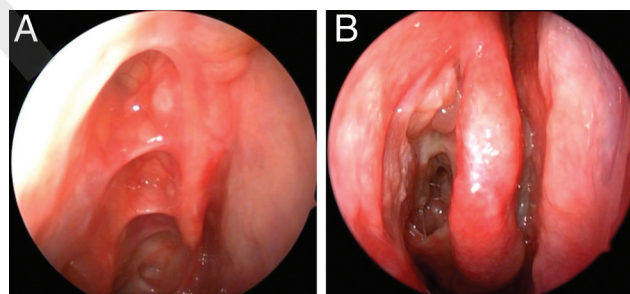


Figure 3. Endoscopic views of patients undergoing extensive endoscopic sinus surgery (EES) (A) and functional endoscopic sinus surgery (FESS) (B) 1 year postoperatively. (A) Mucosal edema is noted in the roof of ethmoid sinus. (B) Mucosal edema is noted in middle meatus and olfactory cleft.

Removal of the MT and ST guarantees adequate space for ventilation and good drainage for sinuses. Meanwhile, removal of the MT and ST may increase airflow to OCs and allow more odorant particles to stimulate the olfactory nerve fiber. A study by Leopold²¹ supported that the volume of the space between the midportion of the septum and the MT correlated strongly with olfactory ability. Although some researchers reported persistence olfactory disturbance after extensive procedures in patients resistant to ESS, which might result from damaged mucosal surface by repeated surgeries (more than three)²² and existence extensive scarring before surgery.²³

With regard to postoperative endoscopic examinations, analysis of our data indicated that EESS resulted in more notable improvement in the E score and the L-K score than did FESS, although the L-K score did not reach statistical significance (change [mean], 7.0 versus 5.8). One important difference between the E score and the L-K score is that the E score covers each sinus and OC but that the L-K score considers “nasal cavity” as an entirety and fails to identify the different outcomes among different structures. In this study, we found that different sinuses had different outcomes. The maxillary sinus and sphenoid sinus had better reepithelialization, whereas the frontal

recess, the roof of ethmoid sinus, and the OC had a strong tendency of mucosa edema. The E score could better reflect the different mucosal healing after ESS. For instance, in our results, the endoscopic view of the nasal cavity and sinuses (EESS), shown in Fig. 3 A, was obviously healthier than those shown in Fig. 3 B (FESS). These two postoperative endoscopic views were both scored as 1 for edema with L-K scores, whereas, in the E scores, these two postoperative endoscopic views were scored as 1/12 (Fig. 3 A) and 7/12 (Fig. 3 B), respectively.

Compared with other MT resection studies, Byun and Lee²⁴ reported that patients with CRSwNP who underwent MT resection had poorer objective surgical outcomes, and they thought that this was related to greater baseline disease burdens. Conversely, Marchioni *et al.*²⁵ found out that MT resection in patients with CRSwNP resulted in better endoscopy improvement. They decided during surgery whether they would resect or preserve the MT. These inconsistent results were possibly related to the different subjects, different baseline disease burdens, and varied criteria for MT resection. Endoscopic results of the EESS studies focused on symptoms, and comparison of endoscopic outcome was not available.

This study was of value because the two groups were well matched with comparable disease burden and was of a single-institute nature. Of note, all surgical procedures were performed by a single surgeon and all the patients had finished 1-year follow-up. Because CRS patients with ASA intolerance are rare in the Chinese population and they had poorer ESS outcome than CRS patients with ASA tolerance asthma based on our previous study and literature review.^{7,26} We especially excluded these patients with ASA intolerance in this study.

The EESS procedures in the present study included partial MT and ST resection, removal of all polyps, and total ethmoidectomy. MT resection was associated with reduced frequency of synechiae and fewer revision surgeries (level of evidence, Ib). The disadvantage was that it removed the important anatomic landmark. Therefore, we preserved the superior, sagittal-oriented portion of the MT as a landmark. Furthermore, just as Bassiouni *et al.*²⁷ pointed out that those with CRSwNP, concomitant asthma had the highest inflammatory load. There was abundant eosinophil infiltration in NP and ethmoid mucosa. FESS that only addresses the sinus ostium fails to significantly reduce the eosinophilic inflammatory load and extensive surgical approach could remove NP and diseased ethmoid mucosa totally to eliminate all inflammatory triggers. Therefore, extensive surgical approach could help perpetuate a vicious cycle of local inflammation, or called "resetting the clock."²⁷ In addition, EESS expanded the time of interval until a revision procedure was required.²⁸ However, we emphasized a meticulous operation, careful preservation of the mucosa around the ostium, and avoidance of deliberate mucosal stripping.

The risk of a remnant MT stump causing frontal recess stenosis has been considered as a solid reason against MT resection. Swanson *et al.*²⁹ demonstrated, in a retrospective analysis, that subsequent frontal sinusitis increased when a total or partial MT resection was performed in mild-to-moderate CRS. However, there was no significant difference between MT resection and preservation in our study and in other studies.^{30–32} In our experiments, adhesion formation required the presence of two raw surfaces or severe inflammation. After MT resection, the space of the frontal recess is widened, and it is not easy to form adhesion. Moreover, Soler *et al.*¹⁸ revealed that the MT resection group was less likely to develop synechiae and to require revision surgery by a mean of a 4.2-year follow-up period. For avoiding cerebrospinal fluid leak, we advocate preserving the superior, sagittal oriented portion of MT, which is attached to the skull base directly. Atrophic rhinitis has been reported³² but was not observed in our study. In addition, a systematic review found that no difference was noted for quality-of-life outcomes, nasal airway resistance, or rates of postoperative sinusitis between the MT resection and preservation groups.³²

However, before more-definitive conclusions may be drawn, several limitations need to be addressed. A clear limitation of the present study was that it was not a randomized design. This limitation may be addressed in future work through a randomized design. In addition, the mere analysis of a subjective outcome of olfactory reduction by the VAS score was an important limitation of this study. Although olfactometry is considered the criterion standard for evaluating olfactory symptoms, a subjective assessment is mandatory in CRS because subjective perception of smell and nasal obstruction are the criteria for performing surgery.³⁴ Furthermore, it was clear the limited numbers of patients available for analysis and the relative short-term follow-up. These limitations may be addressed through increasing numbers of patients and long-term follow-up.

CONCLUSION

Analysis of our prospective data indicated that EESS significantly alleviated the olfactory reduction and/or loss in patients with CRSwNP and with asthma compared with FESS but did not increase the risk of frontal ostium stenosis and other major complications. EESS might be a viable treatment option in this group of patients.

REFERENCES

- Shi JB, Fu QL, Zhang H, et al. Epidemiology of chronic rhinosinusitis: Results from a cross-sectional survey in seven Chinese cities. *Allergy* 70:533–539, 2015.
- Fokkens WJ, Lund VJ, Mullol J, et al. European Position Paper on Rhinosinusitis and Nasal Polyps 2012. *Rhinol Suppl* 3:3 p preceding table of contents, 1–298, 2012.
- Chen F, Luo X, Xu R, et al. Evaluation of airway hyperresponsiveness in chronic rhinosinusitis: Values of sinus computed tomography. *Ann Allergy Asthma Immunol* 113:609–613, 2014.
- Yoshimura K, Kawata R, Haruna S, et al. Clinical epidemiological study of 553 patients with chronic rhinosinusitis in Japan. *Allergol Int* 60:491–496, 2011.
- Smith TL, Mendolia-Loffredo S, Loehrl TA, et al. Predictive factors and outcomes in endoscopic sinus surgery for chronic rhinosinusitis. *Laryngoscope* 115:2199–2205, 2005.
- Van Zele T, Holtappels G, Gevaert P, and Bachert C. Differences in initial immunoprofiles between recurrent and nonrecurrent chronic rhinosinusitis with nasal polyps. *Am J Rhinol Allergy* 28:192–198, 2014.
- Chen FH, Zuo KJ, Guo YB, et al. Long-term results of endoscopic sinus surgery-oriented treatment for chronic rhinosinusitis with asthma. *Laryngoscope* 124:24–28, 2014.
- Masterson L, Tanweer F, Bueser T, and Leong PL. Extensive endoscopic sinus surgery: Does this reduce the revision rate for nasal polyposis? *Eur Arch Otorhinolaryngol* 267:1557–1561, 2010.
- Videler WJ, van Drunen CM, van der Meulen FW, and Fokkens WJ. Radical surgery: Effect on quality of life and pain in chronic rhinosinusitis. *Otolaryngol Head Neck Surg* 136:261–267, 2007.
- Jankowski R, Pigret D, Decroocq F, et al. Comparison of radical (nasalisation) and functional ethmoidectomy in patients with severe sinonasal polyposis. A retrospective study. *Rev Laryngol Otol Rhinol (Bord)* 127:131–140, 2006.
- Global Initiative for Asthma. Global Strategy for Asthma Management and Prevention. 2015. Available from: www.ginasthma.com.
- Lund VJ, and Kennedy DW. Quantification for staging sinusitis. The Staging and Therapy Group. *Ann Otol Rhinol Laryngol Suppl* 167: 17–21, 1995.
- Tsuzuki K, Hinohira Y, Takebayashi H, et al. Novel endoscopic scoring system after sinus surgery. *Auris Nasus Larynx* 41:450–454, 2014.
- Lund VJ, and Kennedy DW. Staging for rhinosinusitis. *Otolaryngol Head Neck Surg* 117:S35–S40, 1997.
- Nathan RA, Sorkness CA, Kosinski M, et al. Development of the asthma control test: A survey for assessing asthma control. *J Allergy Clin Immunol* 113:59–65, 2004.
- Sakpal TV. Sample size estimation in clinical trial. *Perspect Clin Res* 1:67–69, 2010.

17. Havas TE, and Lowinger DS. Comparison of functional endonasal sinus surgery with and without partial middle turbinate resection. *Ann Otol Rhinol Laryngol* 109:634–640, 2000.
18. Soler ZM, Hwang PH, Mace J, and Smith TL. Outcomes after middle turbinate resection: Revisiting a controversial topic. *Laryngoscope* 120:832–837, 2010.
19. Kerrebijn JD, Drost HE, Spoelstra HA, and Knegt PP. If functional sinus surgery fails: A radical approach to sinus surgery. *Otolaryngol Head Neck Surg* 114:745–747, 1996.
20. Jankowski R, Pigret D, and Decroocq F. Comparison of functional results after ethmoidectomy and nasalization for diffuse and severe nasal polyposis. *Acta Otolaryngol* 117:601–608, 1997.
21. Leopold DA. The relationship between nasal anatomy and human olfaction. *Laryngoscope* 98:1232–1238, 1988.
22. Videler WJ, Wreesmann VB, van der Meulen FW, et al. Repetitive endoscopic sinus surgery failure: A role for radical surgery? *Otolaryngol Head Neck Surg* 134:586–591, 2006.
23. Wreesmann VB, Fokkens WJ, and Knegt PP. Refractory chronic sinusitis: Evaluation of symptom improvement after Denker's procedure. *Otolaryngol Head Neck Surg* 125:495–500, 2001.
24. Byun JY, and Lee JY. Middle turbinate resection versus preservation in patients with chronic rhinosinusitis accompanying nasal polyposis: Baseline disease burden and surgical outcomes between the groups. *J Otolaryngol Head Neck Surg* 41:259–264, 2012.
25. Marchioni D, Alicandri-Ciufelli M, Mattioli F, et al. Middle turbinate preservation versus middle turbinate resection in endoscopic surgical treatment of nasal polyposis. *Acta Otolaryngol* 128:1019–1026, 2008.
26. Mendelsohn D, Jeremic G, Wright ED, and Rotenberg BW. Revision rates after endoscopic sinus surgery: A recurrence analysis. *Ann Otol Rhinol Laryngol* 120:162–166, 2011.
27. Bassiouni A, Naidoo Y, and Wormald PJ. When FESS fails: The inflammatory load hypothesis in refractory chronic rhinosinusitis. *Laryngoscope* 122:460–466, 2012.
28. Wu AW, Ting JY, Platt MP, et al. Factors affecting time to revision sinus surgery for nasal polyps: A 25-year experience. *Laryngoscope* 124:29–33, 2014.
29. Swanson P, Lanza D, Vining E, and Kennedy D. The effect of the middle turbinate resection upon the frontal sinus. *Am J Rhinol* 9:191–195, 1995.
30. Stewart MG. Middle turbinate resection. *Arch Otolaryngol Head Neck Surg* 124:104–106, 1998.
31. Giacchi RJ, Lebowitz RA, and Jacobs JB. Middle turbinate resection: Issues and controversies. *Am J Rhinol* 14:193–197, 2000.
32. Choby GW, Hobson CE, Lee S, and Wang EW. Clinical effects of middle turbinate resection after endoscopic sinus surgery: A systematic review. *Am J Rhinol Allergy* 28:502–507, 2014.
33. Moore EJ, and Kern EB. Atrophic rhinitis: a review of 242 cases. *Am J Rhinol* 15:355–361, 2001.
34. Sanjuan de Moreta G, Cardoso-Lopez I, and Poletti-Serafini D. Centripetal endoscopic sinus surgery in chronic rhinosinusitis: A 6-year experience. *Am J Rhinol Allergy* 28:349–352, 2014. □

Copyright of American Journal of Rhinology & Allergy is the property of OceanSide Publications Inc. and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.