In-office, multisinus balloon dilation: 1-Year outcomes from a prospective, multicenter, open label trial

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ABSTRACT

Background: *The objective of this prospective, multicenter study was to assess 1-year changes in sinonasal symptoms and health care use after office-based multisinus balloon dilation.*

Methods: *Adults diagnosed with chronic or recurrent acute rhinosinusitis per the 2007 adult sinusitis guidelines were enrolled in this Institutional Review Board-approved study. Balloon dilation of the maxillary sinuses/ethmoid infundibula with or without frontal or sphenoid ostial dilation was performed in the physician's office under local anesthesia. Intraoperative procedure technical success and subject procedure tolerance were recorded. Efficacy was assessed using the patient-reported 20-item Sino-Nasal Outcome Test (SNOT-20) and Rhinosinusitis Symptom Inventory (RSI). Complications and revision surgeries were also recorded.*

Results: *A total of 313 ostial dilations were attempted and 307 were successfully completed (98.1%) in 81 subjects. Mean procedure tolerance was 2.8 ± 2.2 (0 = no pain; 10 = severe pain). Clinically meaningful and statistically significant ($p < 0.0001$) mean SNOT-20 symptom improvement was observed at 1 and 6 months and sustained through 1 year. The RSI treatment effect for all major rhinosinusitis symptoms was "large" and improvement in each was significant ($p < 0.0001$). Compared with the previous 1-year period, patients reported an average of 2.3 fewer acute sinus infections ($p < 0.0001$), 2.4 fewer antibiotic courses taken ($p < 0.0001$), and 3.0 fewer sinus-related physician visits ($p < 0.0001$) after balloon dilation. No serious device or procedure-related adverse events occurred. One subject (1.3%) underwent revision surgery.*

Conclusion: *In-office, multisinus balloon dilation is safe, effective, and well tolerated. Patients reported significant reductions in both sinonasal symptoms and health care use after balloon dilation. Efficacy observed at 1 and 6 month follow-up was sustained through 1 year with a very low rate of revision surgery.* This study was a part of the clinical trial NCT01612780 registered at www.clinicaltrials.gov

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According to the most recently published national health summary statistics, 29.6 million adults aged ≥18 years suffer from all forms of sinusitis and the number with chronic rhinosinusitis (CRS) has been estimated to be 11.1 million.[1–3] Over 250,000 ambulatory sinus surgeries are performed per year in the United States and the economic burden of CRS remains high at an estimated $8.6 billion annually.[4] Balloon dilation of the maxillary, frontal, and sphenoid sinuses to treat CRS was introduced in 2006 and has been shown to be safe and effective with recent studies, further indicating effectiveness and efficacy with in-office balloon dilation.[5–8] Office-based balloon sinus dilation procedures provide benefits over general anesthesia–based sinus surgery including convenience and quicker recovery while also providing similar symptom improvement at lower overall procedure and postoperative follow-up costs.[8] A prior randomized trial comparing standalone office balloon dilation to functional endoscopic sinus surgery showed similar symptom relief between groups when treating a population of patients with CRS and disease limited to the maxillary and anterior ethmoid sinuses (REMODEL Trial, Cutler *et al*[8]) Our study expands on the study population in the balloon arm of the REMODEL trial by including patients with disease in any sinus. This is the first study to evaluate 1-year outcomes after office balloon dilation with a single multisinus dilation tool (XprESS; Entellus Medical, Inc., Plymouth, MN) in a population of patients with multisinus disease.

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METHODS

Study Design

The objective of this prospective, multicenter study was to assess 1-year changes in sinonasal symptoms and health care use after office-based multisinus balloon dilation. All study centers received protocol training and Western Institutional Review Board approval before enrollment and subjects provided voluntary, informed consent before study participation. There was no study roll-in phase and all physicians were previously trained on preparation and use of the study devices and also had prior experience performing balloon dilation under local anesthesia. Study data were monitored and managed in compliance with Good Clinical Practices. All analyses were performed by independent statisticians.

Subject Selection

Eligible subjects were at least 18 years of age, diagnosed with either CRS or recurrent acute rhinosinusitis (RARS) per the adult sinusitis clinical practice guidelines (2007)[9] and did not respond to medical management including antibiotics and nasal steroids as indicated. Specifically, subjects with CRS had at least 12 weeks of two or more major sinus symptoms, and subjects with RARS had four of more episodes of acute bacterial rhinosinusitis per year without signs or symptoms between episodes. All subjects had documentation of inflammation by either purulent mucous/edema of the middle meatus or ethmoid region or radiographic imaging showing paranasal sinus inflammation. Subjects were required to have a current preoperative computed tomography (CT) scan before enrollment. Maxillary sinus disease was the minimum requirement for study entry but subjects with frontal, sphenoid, and/or ethmoid disease were also included. Subjects who had previously undergone maxillary sinus surgery or nasal surgery within 3 months before enrollment and anyone requiring concomitant sinus or nasal surgery other than turbinate reduction at the time of balloon dilation were not eligible. Additionally, subjects with features consistent with sinus fungal disease were not allowed to participate.

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Table 1 **Baseline SNOT-20 scores and diagnosis by distribution of baseline LM scores**

Baseline LM Score	Subjects *n* (%)	Baseline Mean SNOT-20 Score	CRS Diagnosis		Turbinate Hypertrophy	
			Chronic *n* (%)	Recurrent Acute *n* (%)	Yes with Turbinate Reduction *n* (%)	No *n* (%)
≤3.0	38 (48%)	2.36	31 (44%)	7 (78%)	29 (63%)	9 (26%)
>3.0–8.0	27 (34%)	2.39	26 (37%)	1 (11%)	12 (26%)	15 (44%)
>8.0	15 (19%)	1.75	14 (20%)	1 (11%)	5 (11%)	10 (29%)
Total	80 (100%)	2.26	71 (100%)	9 (100%)	46 (100%)	34 (100%)

LM = Lund-Mackay; SNOT-20 = 20-item Sino-Nasal Outcome Test.

Study Procedure and Operative Outcomes

All subjects underwent transnasal balloon dilation (XprESS; Entellus Medical, Inc.) under local anesthesia in an office setting. Turbinate reduction was permitted as medically indicated for turbinate hypertrophy but no additional concomitant endoscopic sinus surgery or nasal surgery was allowed. Preoperative use of oral sedation and antianxiety medications were at the discretion of the physicians and intravenous sedation and general anesthesia were not permitted. The malleable tip of the balloon device was shaped into the preferred bend configuration for each sinus using a proprietary bending tool to access the targeted sinuses. Ostial cannulation was confirmed using either endoscopy and/or transillumination (PathAssist Light Fiber; Entellus Medical, Inc.). Technical success (number of successful dilations/number of dilation attempts) and anesthesia regimen were documented, and before discharge subjects were asked to rate their overall procedure tolerance using an 11-point numerical rating scale (0 = no pain; 10 = severe pain). Methods to control postoperative bleeding were also recorded. Subjects returned for follow-up at 1 and 6 months and 1 year.

Safety and Efficacy Outcomes

Change in sinonasal symptom severity between baseline and follow-up was assessed using the 20-item Sino-Nasal Outcome Test 20 (SNOT-20)[10–12] and Rhinosinusitis Symptom Inventory (RSI; developed by N. Bhattacharyya, M.D., Boston, MA).[13] Both patient-completed surveys are validated to assess disease-specific symptom severity in subjects with rhinosinusitis.[10–13] Symptoms on the SNOT-20 survey were rated on a scale from "0" (no problem) to "5" (problem as bad as it can be) and the 20 symptoms were further analyzed per the following four subscales: rhinologic symptoms, ear/facial symptoms, sleep function, and psychological issues. A decrease of 0.8 in the mean SNOT-20 score between baseline and follow-up is considered clinically meaningful.[10] The RSI questionnaire rates five major and seven minor rhinosinusitis symptoms on a scale of "0" (absent) to "5" (very severe) and also measures patient-reported medication use, sinus-related physician visits, work/school absenteeism, homebound days, and frequency of acute infections of the nose/sinuses over the 1-year period before and after office balloon dilation. Subject satisfaction with the procedure was assessed at the end of study. Additional outcome measures included serious adverse events and rate of revision surgery.

Sample Size and Statistical Analysis

Study sample size was established to test the hypothesis that the mean, overall SNOT-20 score improves from baseline to 1 year by at least the validated clinically meaningful difference of 0.8.[10] Using this delta, a one-sided alpha of 0.25, and 90% power, a sample size of 19 subjects was adequate to test the hypothesis. However, the sample size was increased to allow for subgroup analyses. Two-sided Student's *t*-tests were used to compare continuous measures and Fisher's exact tests were used to compare categorical measures. Values of $p < 0.05$ were deemed statistically significant. All analyses were performed using SAS Version 9.3 (SAS Institute, Cary, NC).

RESULTS

Study Population

Eighty-two subjects were enrolled and 81 subjects were successfully treated by 10 physician investigators from 10 different medical practices. The mean ± SD age was 50.1 ± 16.7 years and 57.3% were female subjects. Fifty-four (65.8%) subjects had allergies, 16 (19.5%) had asthma or bronchitis, and 15 (18.3%) were smokers. Septal deviation was present in 49 (59.8%) subjects and 4 presented with simple nasal polyps. Seventy-three (89%) subjects were diagnosed with CRS and 9 (11%) were diagnosed with RARS. Subjects failed an average of 3.8 antibiotic courses before enrollment and CRS patients had a mean ± SD baseline Lund-Mackay (LM) score of 5.0 ± 4.2. Distributions of baseline LM score ranges are provided in Table 1. All patients (82; 100%) had maxillary disease, 57 (69.5%) had frontal, 34 (41.5%) had sphenoid, 34 (41.5%) had anterior ethmoid, and 11 (13.4%) had posterior ethmoid disease. Sixteen subjects had prior septoplasty or turbinate reduction. Seventy-six of the 81 patients treated completed 1-year follow-up for a 94% retention rate.

Operative Outcomes

Three hundred thirteen ostial dilations were attempted in 82 subjects and 307 were successfully completed in 81 subjects for an overall sinus dilation success rate of 98.1%. Technical success rates for the frontal, maxillary/ethmoid infundibula, and sphenoid sinus ostia were 100.0 (103/103), 98.8 (160/162), and 91.7% (44/48), respectively. The six unsuccessful dilation attempts occurred in three patients. Two subjects planned for bilateral sphenoid ostial dilation were converted to unilateral treatment because of subject discomfort and one subject planned for bilateral maxillary/sphenoid ostial dilation could not be completed because concha bullosa and middle turbinate rigidity prevented access and cannulation of all ostia planned for treatment. On average, 3.8 ostial dilations were performed per patient (range, 1–6). Forty-six subjects also underwent concomitant turbinate reduction during balloon dilation for treatment of turbinate hypertrophy.

All patients had topical decongestant, topical anesthesia spray, and anesthetic-soaked pledgets administered before the procedure. All but two patients also received local anesthesia injections before balloon dilation. Sixty percent of all subjects received a preoperative oral anxiolytic before the procedure. The overall mean ± SD procedure tolerance as rated by the patients was 2.8 ± 2.2 (0 = no pain; 10 = severe pain). Procedure tolerance was slightly better in those subjects who received a preoperative anxiolytic versus those who did not (2.5 ± 2.4 versus 3.2 ± 1.7), with the difference trending toward significance ($p = 0.159$). There was no difference in procedure tolerance between subjects who underwent standalone balloon dilation (2.8 ± 2.3) versus those who also had concomitant turbinate reduction surgery (2.8 ± 2.1; $p = 0.913$).

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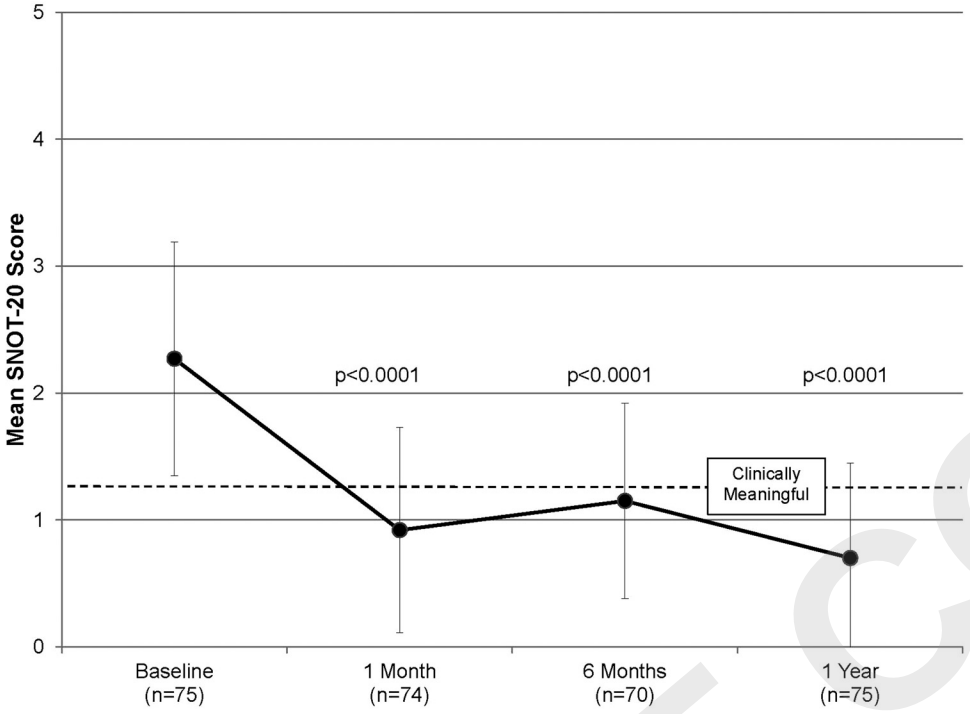

Figure 1. Mean overall 20-item Sino-Nasal Outcome Test (SNOT-20) score at baseline and follow-ups; comparison of mean change from baseline to follow-ups; p value from paired t-test.

Table 2 **Change in SNOT-20 symptom subscales from baseline to 1 yr post–balloon dilation**

Subscale	Baseline (n = 75)	1-Year Change (n = 75)	p Value*
Rhinologic symptoms	2.65 ± 1.07	−1.69 ± 1.13	<0.0001
Ear and facial symptoms	2.05 ± 1.13	−1.51 ± 1.16	<0.0001
Sleep function	2.27 ± 1.53	−1.55 ± 1.56	<0.0001
Psychological issues	2.02 ± 1.23	−1.51 ± 1.25	<0.0001

**Comparison of mean change from baseline to 1-yr follow-up; p value from paired t-test.*
SNOT-20 = 20-item Sino-Nasal Outcome Test.

Safety and Efficacy Outcomes

Sinonasal symptoms improved from a mean ± SD SNOT-20 score of 2.27 ± 0.92 to 0.70 ± 0.75 at 1 year. The symptom score reduction of −1.57 was not only statistically significant ($p < 0.0001$) but was nearly twice the clinically meaningful difference of 0.8. Overall, 78.7% of all subjects experienced clinically meaningful sinus symptom improvement at 1 year. Symptom improvement was clinically meaningful, statistically significant, and was maintained from 1 month follow-up through the end of the study (Fig. 1). Sinonasal symptom improvement across all SNOT-20 subscales was also significant and clinically meaningful through 1 year (Table 2). At the end of the study, 87.8% (65/74) of all subjects remained satisfied with the procedure.

The RSI sinonasal symptom scores at baseline and the 1-year change for each of the five major and seven minor rhinosinusitis symptoms are shown in Table 3. Nasal obstruction and congestion were the most problematic major symptoms at baseline. At 1-year follow-up patients experienced "large" treatment effects for all five of the major symptoms including nasal obstruction, congestion, facial pressure, rhinorrhea, and hyposmia. The changes in RSI health care use and work status from baseline to 1 year after balloon dilation are displayed in Table 4. Reported use of antibiotics dropped significantly from an average of 3.4 ± 2.5 courses to 1.0 ± 1.4 courses ($p < 0.0001$). The proportion of patients who reported using nasal steroids and antihistamines both decreased by 23 percentage points ($p < 0.001$ and $p < 0.0001$, respectively). In the year after balloon dilation, the number of reported sinus-related physician visits dropped significantly from an average of 4.1 ± 3.6 to 1.1 ± 2.4 visits per subject ($p < 0.0001$) and the reported number of acute sinus infections decreased significantly from 3.0 ± 2.8 to 0.70 ± 1.2 ($p < 0.0001$).

No serious device-related or procedure-related adverse events were reported during the study. One serious adverse event, unrelated to either the device or the procedure, was reported after a subject was hospitalized with a tick-borne illness. This subject was treated with intravenous antibiotics and discharged without further sequelae. One (1.3%) subject underwent revision sinus surgery. This subject, who initially received bilateral maxillary ostial dilation, underwent unilateral, left-side maxillary antrostomy, uncinectomy, and ethmoidectomy ~4 months postprocedure and a second left-side maxillary antrostomy ~5 months after the first revision surgery.

Analyses by Sinus Dilation Subgroups

Twenty-two subjects underwent maxillary, frontal, and sphenoid sinus dilation; 32 subjects underwent maxillary and frontal dilation; 5 subjects underwent maxillary and sphenoid dilation; and another 22 subjects underwent maxillary-only treatment. Analysis of patient procedure tolerance revealed there was no significant difference between these sinus dilation subgroups. Figure 2 shows 1-year mean change in SNOT-20 score by sinus dilation subgroup. Mean symptom improvement was clinically meaningful and statistically significant in each subgroup. The clinically meaningful decrease in SNOT-20 of at least 0.8 between baseline and 1-year follow-up on a per subject basis

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Table 3 **Change in RSI sinonasal symptom scores from baseline to 1 yr post–balloon dilation**

Symptom	Baseline (n = 75)	1-Year Change (n = 75)	Effect Size*	p Value#
Major				
Facial pressure	2.8	−2.1	−1.34 (large)	<0.0001
Congestion	3.0	−2.2	−1.39 (large)	<0.0001
Nasal obstruction	3.3	−2.5	−1.61 (Large)	<0.0001
Rhinorrhea	2.7	−2.0	−1.13 (large)	<0.0001
Hyposmia	1.9	−1.5	−0.99 (large)	<0.0001
Minor				
Headache	3.0	−2.1	−1.32 (large)	<0.0001
Fever	0.9	−0.8	−0.68 (moderate)	<0.0001
Halitosis	1.3	−1.0	−0.72 (moderate)	<0.0001
Fatigue	2.8	−1.9	−1.17 (large)	<0.0001
Dental pain	1.3	−1.0	−0.74 (moderate)	<0.0001
Cough	2.0	−1.6	−0.99 (large)	<0.0001
Ear pain	2.2	−1.5	−0.98 (large)	<0.0001

**Effect size: small, <0.5; moderate, 0.5 to <0.8; large, ≥0.8.*
#Comparison of mean change from baseline to 1-yr follow-up; p value from paired t-test.
RSI = Rhinosinusitis Symptom Inventory.

Table 4 **Change in RSI health care use and work status from baseline to 1 yr post–balloon dilation**

Characteristic	n	Baseline	1 yr	Change	p Value*
Proportion using nasal steroids	75	73.3%	50.7%	−22.6%	<0.001
Proportion using antihistamines	75	60.0%	37.3%	−22.7%	<0.0001
Number of antibiotic courses	69	3.4	1.0	−2.4	<0.0001
Number of work/school days missed	72	1.3	0.6	−0.7	0.037
Number of homebound days	72	6.0	0.8	−5.2	<0.0001
Number of sinus-related physicians' visits	74	4.1	1.1	−3.0	<0.0001
Number of acute sinus infections	71	3.0	0.7	−2.3	<0.0001

**Comparison of mean change from baseline to 1-yr follow-up; p value from paired t-test.*
RSI = Rhinosinusitis Symptom Inventory.

revealed that 86.4% of all subjects who underwent multisinus dilation of the maxillary, frontal, and sphenoid ostia experienced meaningful symptom improvement while 77.9, 80.0, and 71.4% of the maxillary-frontal, maxillary-sphenoid and maxillary-only subgroups, respectively, also received clinically meaningful improvement in their sinonasal symptoms.

All sinus dilation subgroups experienced a "large" treatment effect and statistically significant ($p < 0.0001$) improvement in each of the five major RSI sinonasal symptoms. Similarly, all subgroups saw significant reductions in mean number of antibiotic courses ($p < 0.001$), number of sinus-related physician visits ($p < 0.01$), and the number of acute sinus infections ($p < 0.01$) in the year after office balloon dilation.

Analyses by Other Subgroups

Table 5 shows mean SNOT-20 score improvement at 1 year postprocedure for the following characteristics: CRS diagnosis, baseline LM score, presence or absence of diseased ethmoid sinuses, presence or absence of septal deviation, and presence or absence of turbinate hypertrophy. Clinically meaningful (mean change in score of ≥0.8) and statistically significant improvement was obtained for each subgroup. In addition, all subgroups reported statistically significant reductions in mean number of antibiotic courses (Table 6), number of sinus-related physician visits, and the number of acute sinus infections in the year after balloon dilation compared with the year before treatment. Table 7 displays the 1-year change in RSI sinonasal symptom scores from baseline for the patients with turbinate hypertrophy who underwent turbinate reduction along with those without turbinate hypertrophy. Both subgroups experienced a "large" treatment effect and statistically significant ($p < 0.0001$) improvement in each of the five major RSI sinonasal symptoms.

DISCUSSION

In this prospective, multicenter, controlled clinical trial we showed that multisinus balloon dilation of maxillary, frontal, and sphenoid sinuses with and without turbinate reduction was safely performed in physician offices under local anesthesia with a high rate of technical success and patient tolerance. We further showed multisinus balloon dilation resulted in significant improvement in sinonasal symptoms and patients reported reduced sinus medication use (antibiotics, nasal steroids, and antihistamines), reduced sinus-related physician visits, fewer acute sinus infections, and decreased absenteeism from work or school in the year after balloon dilation. Our results also confirmed a high rate of subject satisfaction with the balloon procedure and sustained treatment effectiveness from 1 month through 1 year with minimal need for subsequent revision sinus surgeries.

Enrollment in this study required subjects to have maxillary disease, but because they could also have disease in other sinuses, we were able to evaluate the impact of balloon dilation in patients with concomitant disease in the frontal, sphenoid, and ethmoid sinuses. Over 86% (86.4%) of patients who underwent dilation of all three sinuses (maxillary, frontal, and sphenoid) experienced clinically meaningful symptom improvement whereas 71.4% of the patents who underwent dilation of one sinus (maxillary only)

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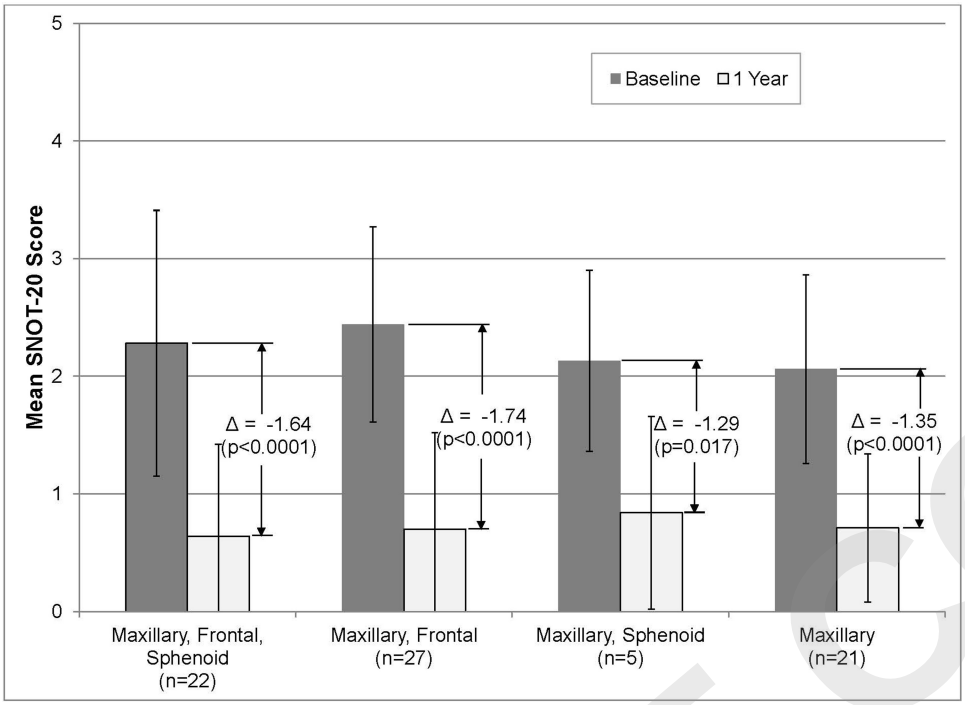

Figure 2. *Mean change in 20-item Sino-Nasal Outcome Test (SNOT-20) score from baseline to 1-year follow-up by sinuses dilated; all subjects with matched-pair data at baseline and 1 year.*

Table 5 **Subgroup analyses: 1-yr change in SNOT-20 score from baseline**

Subgroup	*n*	Baseline ± SD	1-yr Change ± SD	*p* Value*
CRS Diagnosis				
Chronic	67	2.26 ± 0.95	−1.63 ± 1.01	<0.0001
Recurrent acute	8	2.27 ± 0.58	−1.07 ± 0.89	0.011
Baseline LM scores				
≤3.0	34	2.36 ± 0.85	−1.66 ± 0.95	<0.0001
>3.0–8.0	26	2.39 ± 0.80	−1.67 ± 0.97	<0.0001
> 8.0	13	1.75 ± 1.21	−1.05 ± 1.17	0.007
Anterior ethmoid disease				
Yes	30	2.36 ± 1.14	−1.60 ± 1.15	<0.0001
No	45	2.20 ± 0.74	−1.55 ± 0.91	<0.0001
Posterior ethmoid disease				
Yes	9	1.99 ± 1.18	−1.11 ± 1.32	0.036
No	66	2.30 ± 0.88	−1.63 ± 0.95	<0.0001
Septal deviation				
Yes	43	2.15 ± 0.80	−1.65 ± 0.94	<0.0001
No	32	2.42 ± 1.05	−1.46 ± 1.09	<0.0001
Turbinate hypertrophy				
Yes (with turbinate reduction)	41	2.39 ± 0.92	−1.84 ± 0.91	<0.0001
No	34	2.11 ± 0.90	−1.24 ± 1.03	<0.0001

**Comparison of mean change from baseline to 1-yr follow-up; p value from paired t-test.*
LM = Lund-Mackay; SNOT-20 = 20-item Sino-Nasal Outcome Test; CRS = chronic rhinosinusitis.

experienced clinically meaningful improvement. Although this difference was not statistically significant, these results indicate that balloon dilation produces a clinically meaningful treatment effect in patients with single sinus and multisinus disease alike.

Patients also experienced significant, clinically meaningful relief of sinus symptoms irrespective of their baseline LM scores. Individuals with baseline LM scores of >8 had lower patient-reported disease severity (SNOT-20) than subjects with baseline LM scores of ≤8 (Table 1). When sinus symptom improvement was stratified by LM range (Table 5), results indicated that all three LM subgroups responded very well to treatment. This is not surprising because all patients failed medical management and had objective evidence of disease before treatment. Our results showing a treatment benefit across a wide range of LM scores, including the LM ≤3 subgroup, are consistent with earlier published studies that show these patients are good surgical candidates. Hopkins *et al.* reported 21% of patients who underwent conventional sinus surgery had LM scores ≤4 and concluded there was no absolute LM threshold for surgery.[14] Rudmik *et al.* indicated that sinus surgery can provide significant benefit to patients with LM scores ≤3 once patients have failed medical therapy and other possible etiologies have been ruled out.[15] The lack of correlation of LM score to patient symptoms in our study is also

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Table 6 **Subgroup analyses: 1-yr change in RSI health care use from baseline**

Subgroup	No. of Antibiotic Courses				No. of Sinus-Related Physicians' Visits				No. of Acute Sinus Infections			
	n	Baseline	1-yr Change	*p* Value*	*n*	Baseline	1-yr Change	*p* Value*	*n*	Baseline	1 yr Change	*p* Value*
CRS Diagnosis												
Chronic	62	3.2	−2.2	<0.0001	66	3.9	−2.9	<0.0001	65	2.9	−2.3	<0.0001
Recurrent acute	7	5.0	−3.9	0.003	8	5.8	−4.4	<0.001	6	4.8	−3.3	0.002
Baseline LM scores												
≤3.0	30	3.8	−2.9	<0.0001	33	4.7	−3.9	<0.0001	31	3.3	−2.7	<0.0001
>3.0–8.0	26	3.1	−1.8	0.002	26	4.0	−2.2	0.015	26	2.5	−1.6	0.005
>8.0	11	3.2	−2.5	0.004	13	2.9	−2.1	0.003	12	3.2	−2.8	0.008
Anterior ethmoid disease												
Yes	27	4.1	−2.9	<0.0001	29	4.6	−3.7	<0.0001	28	4.0	−3.5	<0.0001
No	42	2.9	−2.0	<0.0001	45	3.8	−2.6	<0.001	43	2.4	−1.6	<0.0001
Posterior ethmoid disease												
Yes	8	4.3	−3.5	0.018	9	4.9	−3.8	0.010	8	5.3	−4.8	0.008
No	61	3.3	−2.2	<0.0001	65	4.0	−2.9	<0.0001	63	2.8	−2.0	<0.0001
Septal deviation												
Yes	41	3.1	−2.5	<0.0001	42	4.1	−3.3	<0.0001	40	2.9	−2.5	<0.0001
No	28	3.8	−2.2	<0.001	32	4.1	−2.6	<0.001	31	3.2	−2.1	<0.001
Turbinate hypertrophy												
Yes (with turbinate reduction)	37	3.0	−2.2	<0.0001	40	2.9	−2.3	<0.0001	39	2.7	−2.2	<0.0001
No	32	3.8	−2.6	<0.0001	34	5.5	−3.9	<0.0001	32	3.5	−2.6	<0.0001

**Comparison of mean change from baseline to 1-yr follow-up; p value from paired t-test.*
RSI = Rhinosinusitis Symptom Inventory; LM = Lund-Mackay; CRS = chronic rhinosinusitis.

Table 7 **Subgroup analyses: 1-yr change in RSI sinonasal symptom scores from baseline**

Symptom	Turbinate Hypertrophy with Turbinate Reduction				No. Turbinate Hypertrophy			
	Baseline	1-yr Change	Effect Size*	*p* Value#	Baseline	1-yr Change	Effect Size*	*p* Value#
Major								
Facial pressure	2.9	−2.5	−1.75 (Large)	<0.0001	2.7	−1.6	−1.01 (Large)	<0.0001
Congestion	3.0	−2.4	−1.62 (Large)	<0.0001	3.0	−2.0	−1.16 (Large)	<0.0001
Nasal obstruction	3.4	−2.7	−1.84 (Large)	<0.0001	3.2	−2.1	−1.40 (Large)	<0.0001
Rhinorrhea	2.6	−2.1	−1.26 (Large)	<0.0001	2.8	−1.9	−0.99 (Large)	<0.0001
Hyposmia	1.7	−1.5	−1.04 (Large)	<0.0001	2.2	−1.6	−0.93 (Large)	<0.0001
Minor								
Headache	3.1	−2.3	−1.47 (Large)	<0.0001	2.9	−1.9	−1.16 (Large)	<0.0001
Fever	1.0	−1.0	−0.81 (Large)	<0.0001	0.8	−0.7	−0.54 (Moderate)	0.004
Halitosis	1.4	−1.1	−0.79 (Moderate)	<0.0001	1.3	−0.9	−0.63 (Moderate)	0.001
Fatigue	2.8	−2.1	−1.27 (Large)	<0.0001	2.8	−1.6	−1.04 (Large)	<0.0001
Dental pain	1.2	−1.1	−0.82 (Large)	<0.0001	1.4	−1.0	−0.67 (Moderate)	0.001
Cough	2.3	−1.8	−1.17 (Large)	<0.0001	1.7	−1.3	−0.81 (Large)	<0.0001
Ear pain	2.2	−1.5	−1.17 (Large)	<0.0001	2.1	−1.5	−0.84 (Large)	<0.0001

**Effect size: small, <0.5; moderate, 0.5 to <0.8; large, ≥0.8.*
#Comparison of mean change from baseline to 1-yr follow-up; p value from paired t-test.
RSI = Rhinosinusitis Symptom Inventory.

consistent with the findings of numerous other studies and amplifies the importance of using CRS-specific symptom severity measures such as the SNOT-20 and RSI over that of CT findings.[16–20]

Fifty-seven percent of patients initially presented with turbinate hypertrophy and underwent concomitant turbinate reduction. Results were as good as in those patients without turbinate hypertrophy who underwent standalone balloon dilation. In addition, 40% of patients followed through 1 year initially presented with anterior ethmoid disease and their outcomes were as good as those without anterior ethmoid disease. This is the fourth study to show that patients with preprocedure anterior ethmoid disease experience clinically meaningful and statistically significant improvement in sinus

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symptoms after balloon dilation of the ethmoid infundibulum without requiring subsequent ethmoidectomy.[5,7,8,21]

Office-based rhinology procedures offer cost savings over similar procedures performed in an ambulatory surgery center or hospital operating room.[22] However, the potential economic benefits are irrelevant if physicians can not control patient comfort and achieve a high rate of technical and follow-up success. In our study, patient tolerance (2.8) was very good and within the range reported in other balloon studies where patients were treated in the physician's office (range, 2.7–4.5).[5,7] This study further indicates that patient comfort during multisinus balloon dilation alone or when combined with turbinate reduction surgery can be successfully managed with local anesthesia. We also found use of preoperative nasal decongestant useful in reducing the likelihood of instrument and device contact with nasal mucosa, which is considered to be one source of discomfort during nasal procedures.[23] Our technical success rate of 98.1% is also consistent with technical success data aggregated across eight other published prospective multicenter studies where dilation of 1785 maxillary, frontal, and sphenoid sinus ostia was successfully completed in 1871 attempts with an overall technical success rate of 95.4%.[5–8,24–27]

Prospective randomized and non-randomized studies have further established RARS or ethmoid disease can be effectively managed with office balloon dilation.[5,7,8,21] Results from our study have also shown that sinus symptom improvement remains significantly better than baseline from 1-month post–balloon dilation out to 1 year post–balloon dilation. This is consistent with several other previous balloon dilation study results that have shown stable sinus symptom improvement from 1 week out to 2 years post–balloon dilation and further supports 6-month follow-up is an acceptable long-term end point.[21,25,28,29]

A study limitation is that the SNOT-20 and RSI surveys, although both validated, are subject to recall bias because they are based on patient-reported events. Furthermore, the absence of a control group in our study does not allow for an assessment of the placebo effect or other variables that could potentially confound our results. However, considering the improvement in symptom severity, high patient retention, and low revision rate data from our study compared with the reported trends across other balloon studies with data out through 2 years, the quantity and consistency of our data suggest it is unlikely the placebo effect played a role in the reported outcomes. The fact that the SNOT-20 and RSI surveys showed similar, consistent results to each other for all of the analyses performed in our study provides further evidence of their validity and usefulness.

The timing between the acquisition of the preoperative CT scan and failure of medical management was not specified and we did not mandate postoperative care. Instead, physicians provided postoperative care in accordance with each patient's disease and clinical practice guidelines. Our methodology was similar to the one used by both the American Rhinologic Society Study Group to compare medical management to surgery in the treatment of CRS and by Smith *et al.* to assess the impact of medical therapy in patients with refractory CRS.[30] Because each patient in our study failed medical management before enrollment and patient-reported postoperative medication decreased significantly, the likelihood that our results were confounded by changes in postoperative care is very low. Recent literature has also shown patients who fail medical management do not experience clinically significant improvement while continuing to receive medical therapy.[31]

Despite these limitations, this study provides 1-year efficacy data to supplement earlier office balloon dilation studies with shorter follow-up and also shows that patients with one of the most common patterns of CRS—ostiomeatal complex disease (includes maxillary, frontal, and anterior ethmoid disease)—can be treated effectively with office balloon dilation.[32,33]

CONCLUSION

Adults exhibiting CRS symptoms despite extensive medical therapy who present with disease in the maxillary, frontal, sphenoid, and anterior ethmoid sinuses experience significant and persistent relief of symptoms and low revision rates when treated with a malleable-tipped multisinus balloon dilation tool in the office. Ostial dilation can also be performed safely and comfortably in awake patients using local anesthesia. Patient-reported sinonasal symptom severity; antibiotic, nasal steroid, and antihistamine use; sinus-related physician visits; acute sinus infections; and work/school attendance are all reduced significantly and are sustained through 1 year. Effectiveness is similar whether subjects have isolated maxillary disease or multisinus disease affecting the maxillary, frontal, sphenoid, or anterior ethmoid sinuses.

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REFERENCES

1. Schiller JS, Lucas JW, and Peregoy JA. Summary health statistics for U.S. adults: National Health Interview Survey, 2011. National Center for Health Statistics. Vital Health Stat. 10:1–207, 2012.
2. Bhattacharyya N. Incremental health care utilization and expenditures for chronic rhinosinusitis in the United States. Ann Otol Rhinol Laryngol 120:423–427, 2011.
3. Halawi AM, Smith SS, and Chandra RK. Chronic rhinosinusitis: Epidemiology and cost. Allergy Asthma Proc 34:328–334, 2013. (DOI: 10.2500/aap.2013.34.3675.)
4. Bhattacharyya N. Ambulatory sinus and nasal surgery in the United States: Demographics and perioperative outcomes. Laryngoscope 120:635–638, 2010.
5. Cutler J, Truitt T, Atkins J, et al. First clinic experience: Patient selection and outcomes for ostial dilation for chronic rhinosinusitis. Int Forum Allergy Rhinol 1:460–465, 2011.
6. Albritton FD IV, Casiano RR, and Sillers MJ. Feasibility of in-office endoscopic sinus surgery with balloon sinus dilation. Am J Rhinol Allergy 26:243–248, 2012.
7. Karanfilov B, Silvers S, Pasha R, et al. Office-based balloon sinus dilation: A prospective, multicenter study of 203 patients. Int Forum Allergy Rhinol 3:404–411, 2013.
8. Cutler J, Bikhazi N, Light J, et al. Standalone balloon dilation versus sinus surgery for chronic rhinosinusitis: A prospective, multicenter, randomized, controlled trial. Am J Rhinol Allergy 27:416–422, 2013.
9. Rosenfeld RM, Andes D, Bhattacharyya N, et al. Clinical practice guideline: Adult sinusitis. Otolaryngol Head Neck Surg 137:S1–S31, 2007.
10. Piccirillo JF, Merritt MG Jr, and Richards ML. Psychometric and clinimetric validity of the 20-Item Sino-Nasal Outcome Test (SNOT-20). Otolaryngol Head Neck Surg 126:41–47, 2002.
11. Pynnonen MA, Kim HM, and Terrell JE. Validation of the Sino-Nasal Outcome Test 20 (SNOT-20) domains in nonsurgical patients. Am J Rhinol Allergy 23:40–45, 2009.
12. Chester AC, and Sindwani R. Symptom outcomes in endoscopic sinus surgery: A systematic review of measurement methods. Laryngoscope 117:2239–2243, 2007.
13. Bhattacharyya N. The economic burden and symptom manifestations of chronic rhinosinusitis. Am J Rhinol 17:27–32, 2003.

DO NOT COPY

14. Hopkins C, Browne JP, Slack R, et al. The Lund-Mackay staging system for chronic rhinosinusitis: How is it used and what does it predict? Otolaryngol Head Neck Surg 137:555–561, 2007.
15. Rudmik L, Mace J, and Smith T. Low-stage computed tomography chronic rhinosinusitis: What is the role of endoscopic sinus surgery? Laryngoscope 121:417–421, 2011.
16. Bhattacharyya T, Piccirillo J, and Wippold FJ II. Relationship between patient-based descriptions of sinusitis and paranasal sinus computed tomographic findings. Arch Otolaryngol Head Neck Surg 123:1189–1192, 1997.
17. Jones NS. CT of the paranasal sinuses: A review of the correlation with clinical, surgical and histopathological findings. Clin Otolaryngol Allied Sci 27:11–17, 2002.
18. Wabnitz DA, Nair S, and Wormald PJ. Correlation between preoperative symptom scores, quality-of-life questionnaires, and staging with computed tomography in patients with chronic rhinosinusitis. Am J Rhinol 19:91–96, 2005.
19. Zheng Y, Zhao Y, Lv D, et al. Correlation between computed tomography staging and quality of life instruments in patients with chronic rhinosinusitis. Am J Rhinol Allergy 24:e41–e45, 2010.
20. Soler ZM, Rudmik L, Hwang PH, et al. Patient-centered decision making in the treatment of chronic rhinosinusitis. Laryngoscope 123:2341–2346, 2013.
21. Stankiewicz J, Truitt T, Atkins J, et al. Two-year results: Transantral balloon dilation of the ethmoid infundibulum. Int Forum Allergy Rhinol 2:199–206, 2012.
22. Prickett KK, Wise SK, and DelGaudio JM. Cost analysis of office-based and operating room procedures in rhinology. Int Forum Allergy Rhinol 2:207–211, 2012.
23. Snidvongs K, and Harvey RJ. Nasal and sinus anesthesia for office procedures. In Office-Based Rhinology: Principles and Techniques. San Diego, CA. Patel ZM, Wise SK, and DelGaudio JM (Eds). Plural, 54, 2013.
24. Plaza G, Eisenberg G, Montojo J, et al. Balloon dilation of the frontal recess: A randomized clinical trial. Ann Otol Rhinol Laryngol 120: 511–518, 2011.
25. Brodner D, Nachlas N, Mock P, et al. Safety and outcomes following hybrid balloon and balloon-only procedures using a multifunction, multisinus balloon dilation tool. Int Forum Allergy Rhinol 3:652–658, 2013.
26. Achar P, Duvvi S, and Kumar B.N. Endoscopic dilatation sinus surgery (FEDS) versus functional endoscopic sinus surgery (FESS) for treatment of chronic rhinosinusitis: A pilot study. ACTA Otorhinolaryngol Ital 32:314–319, 2012.
27. Bolger WE, Brown CL, Church CA, et al. Safety and outcomes of balloon catheter sinusotomy: A multicenter 24-week analysis in 115 patients. Otolaryngol Head Neck Surg 137:10–20, 2007.
28. Weiss RL, Church CA, Kuhn FA, et al. Long-term outcome analysis of balloon catheter sinusotomy: Two-year follow-up. Otolaryngol Head Neck Surg 139:S38–S46, 2008.
29. Soler ZM, and Smith TL. Quality-of-life outcomes after endoscopic sinus surgery: How long is long enough? Otolaryngol Head Neck Surg 143:621–625, 2010.
30. Smith TL, Kern RC, Palmer JN, et al. Medical therapy vs surgery for chronic rhinosinusitis: A prospective, multi-institutional study. Int Forum Allergy Rhinol 1:235–241, 2011.
31. Smith KA, and Rudmik L. Impact of continued medical therapy in patients with refractory chronic rhinosinusitis. Int Forum Allergy Rhinol 4:34–38, 2014.
32. Babbel RW, Harnsberger HR, Sonkens J, and Hunt S. Recurring patterns of inflammatory sinonasal disease demonstrated on screening sinus CT. AJNR Am J Neuroradiol 13:903–912, 1992.
33. Leung RM, Kern RC, Conley DB, et al. Osteomeatal complex obstruction is not associated with adjacent sinus disease in chronic rhinosinusitis with polyps. Am J Rhinol Allergy 25:401–403, 2011. □

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