Office-based balloon sinus dilation: A prospective, multicenter study of 203 patients

Article *in* International Forum of Allergy and Rhinology · May 2013

Impact Factor: 2.37 · DOI: 10.1002/alr.21112 · Source: PubMed

6 authors, including:

Ashley Sikand

5 PUBLICATIONS **22** CITATIONS

SEE PROFILE

Alan H Shikani

Union Memorial Hospital

50 PUBLICATIONS **356** CITATIONS

SEE PROFILE

Michael Sillers

Alabama Nasal and Sinus Center, Birmingha…

45 PUBLICATIONS **1,380** CITATIONS

SEE PROFILE

Office-based balloon sinus dilation: a prospective, multicenter study of 203 patients

Boris Karanfilov, MD[1], Stacey Silvers, MD[2], Raza Pasha, MD[3], Ashley Sikand, MD[4], Alan Shikani, MD, FACS[5], Michael Sillers, MD[1] and for the ORIOS2 Study Investigators

Background: **Balloon sinus dilation (BSD) is an increasingly used tool in endoscopic sinus surgery (ESS). The tissue-sparing nature of the instrumentation allows for properly selected patients to undergo office-based procedures under local anesthesia.**

Methods: **This was an Institutional Review Board (IRB)-approved, prospective, 14-center trial. Patients (n = 203) requiring ESS for medically refractory chronic sinusitis underwent transnasal BSD treatment in an office setting under local anesthesia. Safety, tolerability, technical success, clinical efficacy (20-item Sino-Nasal Outcome Test [SNOT-20]), and radiographic outcome (Lund-Mackay [LMK] score) of ESS with BSD in the office setting were assessed. Subjects were followed at 2, 8, and 24 weeks.**

Results: **A total of 552 sinuses were dilated in 203 patients: 47.6% maxillaries, 45.5% frontals, and 6.9% sphenoids. Seventy-seven patients were revisions of prior ESS. The mean number of sinuses dilated per subject was 2.7. Technical dilation success was 93.3%, 90.5%, and 93.7% for maxillary, sphenoid, and frontal sinuses, respectively. SNOT-20 and LMK computed tomography (CT) scoring showed statistically significant improvement at 24 weeks ($p < 0.0001$) and clinically significant improvement in quality of life. The procedure was reported as tolerable or highly tolerable by 82.3% of patients. There were 0.15 postoperative debridements per patient and the majority returned to normal activity within 48 hours. One (0.5%) procedure-related adverse event related to periorbital swelling was reported, which spontaneously resolved shortly after the procedure without further sequelae.**

Conclusion: **Performance of ESS with BSD in the office under local anesthesia is feasible, well-tolerated, safe, and effective. Twenty-four week follow-up demonstrates clinical and statistical improvement in patient quality of life and radiographic outcomes.** © 2012 ARS-AAOA, LLC.

Key Words:
paranasal sinuses; sinusitis; local anesthesia; office surgery; outcomes assessment

How to Cite this Article: Karanfilov B, Silvers S, Pasha R, Sikand A, Shikani A, Sillers M; for the ORIOS2 Study Investigators. Office-based balloon sinus dilation: a prospective, multicenter study of 203 patients. *Int Forum Allergy Rhinol*. 2012;00:X-XX.

Sinusitis is a highly prevalent condition, affecting approximately 13% of the U.S. population.[1] A significant proportion suffers from sinusitis chronically, which is commonly treated with maximal medical therapy. Unfortunately, medical therapy can fail to alleviate symptoms in many patients, at which point endoscopic sinus surgery (ESS) is typically considered.[2] It has been estimated that over 500,000 patients undergo ESS each year in the US.[3]

Balloon sinus dilation (BSD) was introduced in 2006 as a tool used in ESS to dilate sinus ostia and sinus transition spaces without requiring tissue excision. It has since been demonstrated that the use of balloon catheters in ESS results in long-term reduction in symptomatic burden for

[1]*Ohio Sinus Institute, Dublin, OH;* [2]*Madison ENT & Facial Plastic Surgery, New York, NY;* [3]*Pasha Snoring & Sinus Center, Houston, TX;* [4]*Ear, Nose & Throat Consultants of Nevada, Las Vegas, NV;* [5]*Maryland Nose and Sinus Center, Baltimore, MD;* [6]*Alabama Nasal and Sinus Center, Birmingham, AL*

Correspondence to: Boris Karanfilov, MD, Ohio Sinus Institute, 5378 Avery Road, Dublin, OH 43016; e-mail: bk@ohiosinus.com

Funding sources for the study: Acclarent, Inc. (Menlo Park, CA) provided financial and logistic sponsorship for the study, as well as data monitoring, data analysis, and assistance in drafting the manuscript.
Potential conflict of interest: Boris Karanfilov, Stacey Silvers, and Ashley Sikand are consultants for Acclarent, Inc. Raza Pasha is a consultant for Acclarent, Inc., and Medtronic, Inc. Alan Shikani, has no conflicts of interest. Michael Sillers is a consultant for Acclarent, Inc. (Scientific Advisory Board).
Presented orally at the ARS Annual Spring Meeting in April 2012, San Diego, CA.
Public clinical trial registration: http://clinicaltrials.gov/show/NCT01107379. Optimization and Refinement of Technique in In-Office Sinus Dilation 2 (ORIOS2).

Received: 14 March 2012; Revised: 4 September 2012; Accepted: 25 September 2012
DOI: 10.1002/alr.21112
View this article online at wileyonlinelibrary.com.

chronic rhinosinusitis (CRS) patients, and the technology is associated with a strong safety profile.[4–6] The nature of the balloon catheter instrumentation affords the surgeon the opportunity to dilate sinus ostia with minimal manipulation of the tissue and structures, thereby facilitating a procedure that can be conducted in an office-setting under local anesthesia for properly selected patients. Office-based dilation eliminates the risk associated with general anesthesia and presents the potential for considerable cost savings through avoidance of high-cost hospital or ambulatory surgery settings. In addition, patient convenience benefits may be realized through office procedures under local anesthesia.

The objective of this prospective multicenter study is to evaluate office-based dilation under local anesthesia using validated outcome measures on a large number of patients and including a broad spectrum of sinus disease (frontal, maxillary, and sphenoid sinuses, mild to moderate polyps, mild to moderate ethmoid disease, and primary or revision subjects). Additionally, reporting of adverse events, technical success rates, and patient tolerability data will inform expectations for surgeons considering adding office-based BSD to their treatment armamentarium.

Patients and methods

Study overview

This is a multicenter prospective study of adult patients with CRS unresponsive to maximal medical management. Patients who were candidates for and had planned endoscopic sinus surgery were offered the option of office-based sinus surgery using transnasal BSD technology (Acclarent, Inc., Menlo Park, CA) under local anesthesia. Between April 2010 and April 2011, 203 patients were enrolled at 14 centers in the United States and followed for up to 24 weeks postprocedure. Institutional Review Board (IRB) approval was obtained for each investigational site, and all patients signed informed consent prior to enrollment. Subject data were maintained according to Human Subject Research standards and Good Clinical Practice.

Inclusion and exclusion criteria

Adult patients (18 years old and over) diagnosed with CRS who failed >3 weeks of maximal medical therapy were considered candidates for the study. The minimum maximal medical therapy used prior to being considered a surgical candidate included 3 to 6 weeks of broad-spectrum or culture-directed antibiotics and 3 to 6 weeks of intranasal steroid spray and/or oral steroids if polyps or severe inflammation were present. Antihistamines and/or decongestants were prescribed as clinically indicated. Nasal saline irrigation was routinely used throughout the treatment course. All patients met the definition of CRS as per the American Academy of Otolaryngology Head Neck Surgery Clinical Practice Guideline (2007),[7] including 12 weeks or longer of 2 or more major signs/symptoms and documentation of inflammation by purulent mucus/edema, presence of polyps, or radiographic imaging. All patients had a current preoperative computed tomography (CT) scan confirming mucosal disease and/or obstruction consistent with CRS, and all patients had planned endoscopic surgery prior to being considered as candidates for the study.

Patients with cystic fibrosis, sinonasal tumors or obstructive lesions limiting access, history of facial trauma, or ciliary dysfunction were excluded. Severe polyposis (grade 3) was also an exclusion criterion, where grade 1 was "mild polyposis, small polyps not reaching the upper edge of the inferior turbinate, causing only slight obstruction," grade 2 was "moderate polyposis, medium-sized polyps reaching between the upper and lower edges of the inferior turbinate and causing some obstruction," and grade 3 was "severe polyposis, large polyps reaching below the lower edge of the inferior turbinate and causing total or almost total obstruction."[8] Additionally, patients with a planned septoplasty, ethmoidectomy, turbinectomy, or other non-sinus procedure were excluded. Presence of ethmoid disease (anterior and/or posterior), however, was not an exclusion criteria. Pregnant or lactating women and subjects already enrolled in other CRS studies were excluded.

Procedure

All procedures were conducted in the physician office setting using local anesthesia, supplemented by anxiolytic and/or oral analgesic per investigator discretion. General anesthesia and intravenous conscious sedation were not permitted. Specific local anesthesia protocol was at the discretion of the study investigator, but routinely included aerosolized anesthetics followed by soaked cottonoid or pledget allowed to dwell on the mucosa followed by local infiltration of anesthetic. Transnasal balloon catheter dilation instruments were used, guided by fiber optic–illuminated guidewire (Relieva Luma® or Relieva Luma Sentry™; Acclarent, Inc., Menlo Park, CA) to confirm sinus access. The diameter and length of the sinus balloon catheter (Relieva Solo Pro™; Acclarent, Inc.) was chosen by the investigator as appropriate for the targeted anatomy; 5-, 6-, and 7-mm diameter and 16- or 24-mm length balloons were available. Balloons were dilated to no more than 12 atmospheres and removed immediately after dilation. Sinus irrigation using an intrasinus irrigation catheter (Relieva Vortex™; Acclarent, Inc.) was performed at surgeon discretion after dilation.

Primary and secondary outcome measures

The primary endpoints were evaluation of intrapatient change in 20-item Sino-Nasal Outcome Test (SNOT-20) and Lund-Mackay CT scores between baseline and 24 weeks post-procedure.[9] The SNOT-20 is a validated sinus-specific quality of life (QOL) instrument consisting of 20 questions, each of which is rated from 0 to 5 (0 = "no problem," 5 = "problem as bad as it can be").[10] A decrease of

0.8 in the mean SNOT-20 score is considered clinically significant, as determined by Piccirrillo et al.[10]

Secondary outcome measures included safety, technical success, patient tolerability and pain, patient satisfaction, return to normal activity, need for postoperative debridement, and need for revision surgery. All outcome analysis was conducted on the intent to treat population, which included those subjects requiring revision. Safety was determined by adverse event collection and classification (serious or nonserious, device-related or not device-related) intra- and postprocedurally. Technical success was defined as the targeted sinus being successfully dilated, as determined by intraoperative endoscopy. Sinus access was confirmed by transcutaneous sinus illumination mediated by the illuminated guidewire tip (frontal/maxillary) or endoscopic visualization of the successfully accessed sinus (sphenoid). Sinus dilation was confirmed by direct endoscopic visualization of the dilated sinus. For the maxillary sinus, it was not possible to directly visualize the sinus ostium in all cases due to the intact uncinate process, in which case successful dilation was confirmed via visualization of balloon inflation and displacement of the uncinate process. Tolerability was rated on a 0 to 10 scale at the conclusion of the procedure, with 0 to 2 defined as "highly tolerable," 3 to 5 as "tolerable," 6 to 8 as "somewhat tolerable," and 9 to 10 as "not tolerable." Pain was rated on a 0 to 10 scale at the conclusion of the procedure, with 0 = "no pain" and 10 = "worst pain."

The patients reported on which postoperative day after their sinus surgery they returned to work or equivalent obligations. A response of "1" indicated the first day after surgery. Patient satisfaction with the procedure was evaluated by the questions: "I would recommend this procedure to my family or friends" and "I would have this procedure again," with options of "yes," "no," or "not sure."

In addition, it was anticipated that some patients with mild to moderate ethmoid disease would be enrolled in the study despite the fact that ethmoidectomy would not routinely be performed. This presented an opportunity to study the progression of ethmoid disease when peripheral sinuses were dilated. A subgroup analysis for patients with preoperative radiographic evidence of ethmoid disease was performed to evaluate change in ethmoid-only LMK subscore (eLMK, total maximum bilateral score of 8) in the absence of ethmoidectomy.[9]

Follow-up and study arms

Patients were followed postoperatively at 2 weeks, 8 weeks, and 24 weeks. Diagnostic nasal endoscopy was performed at each visit, as was a recording of adverse events. SNOT-20 patient surveys were completed preoperatively and at each follow-up visit. CT scanning was performed preoperatively and at 24 weeks. A current baseline CT was required but the specific timing of the CT was not standardized with respect to medical therapy failure. As in Smith et al.,[11] postoperative medical therapy was not standardized but was determined by each investigator and customized to each patient's disease.

There were 3 prospectively-defined study cohorts. The *lead-in* cohort consisted of each investigator's first cases where all targeted sinuses were successfully dilated (minimum of 3 cases), except for 4 investigators who had participated in a prior study investigating in-office balloon dilation. The lead-in cases therefore represent the investigator's initial experience of in-office BSD. The *standard enrollment* cohort consisted of each investigator's post–lead-in cases up to approximately 15 cases. The *extended enrollment* cohort consisted of enrolled subjects for any site after the first 15 cases, to permit subgroup analysis of high-enrolling sites. All inclusion, exclusion, and study endpoints were identical for all cohorts with the exception that 24-week follow-up and CT scan was optional for the extended enrollment cohort.

Sample-size calculations and statistical analyses

The sample size was chosen to ensure sufficient power to detect a significant intrapatient change in SNOT-20 and LMK scores. Using an 80% power and a conservative alpha of 0.01 to accommodate 2 primary endpoints, results from operating-room–based sinus dilation[12] suggested that less than 20 patients would be needed to detect statistically significant change in the primary endpoints. However, since 1 of the multiple secondary endpoints was procedural safety, a much larger enrollment of approximately 200 patients was planned. The upper boundary of the 1-sided 95% confidence interval (CI) for 0 serious device-related adverse events among 200 subjects is 1.5%. Given the relatively low rate of adverse events in sinus surgery generally, the investigators felt that a 200-patient prospective study was necessary to provide sufficient evidence of procedural safety.

All adverse events reported by clinical sites were reviewed by the respective Investigator and the Medical Monitor and adjudicated for seriousness and causality with the device. Data from standardized case report forms were entered into a relational database. Descriptive statistics and analyses (means, standard deviations [SD], and CIs) were calculated using SAS 9.2 (SAS Institute, Cary, NC). Categorical variables are presented as proportions with Clopper-Pearson exact 95% CIs.

Results

Baseline characteristics

A total of 203 patients were enrolled in the 3 cohorts (36 lead-in, 84 standard enrollment, 83 extended enrollment). The average age ± SD was 48.6 ± 15.4 years (range, 20–88) and 46.8% were male. Seventy-seven patients (38.1% of 202 subjects reporting) had prior sinus surgery. Polyps were present in 17 subjects (8.4%), which included 15 subjects presenting with grade 1 and 2 subjects with grade 2 polyps. All 203 patients (100%) completed

the procedure-related reporting (technical success, procedural adverse events). Ninety-three (77.5%) of lead-in and standard enrollment cohort subjects were followed to 24 weeks as required per protocol. Seventy-seven of the 83 (92.8%) subjects in the extended enrollment cohort were followed to at least 8 weeks as required per protocol, with 53 of 83 (63.9%) exiting after the 8-week follow-up and an additional 24 of 83 (28.9%) completing the optional 24-week visit.

Operative data, technical success, and safety

Dilation was attempted for 592 sinuses, with 552 (93.2%) successful. A total of 251 of 268 (93.7%) frontal sinuses, 263 of 282 (93.3%) maxillary sinuses, and 38 of 42 (90.5%) sphenoid sinuses were successfully dilated. Anatomical variation/anatomy was the most common reason for unsuccessful dilation for 22 sinuses. Other reasons provided were intolerance (6), disease (4), scarring (2), and polyps (1). For 5 sinuses, the reason for unsuccessful dilation was not provided. Technical dilation success for subjects with or without polyps at baseline was 89.1% and 93.5%, respectively. Technical success for revision or primary sinus interventions was 94.2% and 93.4%, respectively. An average of 2.7 ± 1.44 sinuses was dilated for each patient. Of the 203 enrolled patients, 71.9% had at least 1 frontal, 74.9% had at least 1 maxillary, and 11.3% had at least 1 sphenoid sinus dilated. Six patients (3.0%) had concurrent polypectomy, 2 patients (1.0%) had uncinectomy, and 4 patients (2.0%) had ethmoidectomy performed in office. The most common balloon size used was 6×16 (used in 58.1% of targeted sinuses) with 24.2% of sinuses dilated using a 7-mm-diameter balloon and 14.0% using a 5-mm-diameter balloon. Intrasinus irrigation was conducted on 42 patients (20.7%).

The anesthesia regimen generally consisted of aerosolized local anesthetic and decongestant, followed by topical anesthetic soaked on a cottonoid or pledget and then infiltration. Approximately one-half of the investigative centers used 1% to 4% tetracaine for topical anesthetic while the remainder used 4% lidocaine. Injections (0.5% or 1% lidocaine with 1:100,000 epinephrine) were recorded in 91.6% of cases. Two subjects (1.0%) received oral narcotics, 33.0% received oral anxiolytics such as lorazepam, diazepam, or alprazolam, and 9.4% received both oral narcotic and anxiolytics. No oral medication prior to the procedure was received by 56.7% of the patients.

All 203 enrolled subjects were included in the analysis of adverse events. There were no device-related or procedure-related serious adverse events. There was 1 (0.5%) serious non-device, non-procedure–related adverse event—1 patient was hospitalized due to pneumonia approximately 2 months after the procedure. One (0.5%) procedure-related adverse event related to periorbital swelling was reported, which spontaneously resolved shortly after the procedure without further sequelae. This patient had a narrow, tight infundibulum that necessitated manipulation of the uncinate process with a ball probe to permit access of the sinus guide. Once done, the maxillary sinus was successfully cannulated and dilated. The day following the sinus surgery, the patient blew her nose and developed some mild periorbital ecchymosis that resolved within approximately 24 hours. There were no other orbital or ocular sequelae.

Primary outcome endpoints

Table 1 shows the SNOT-20 results for all patients at all time points, as well as the intrapatient change for matched pairs (QOL improvement for subjects with data at both baseline and the specified time point). The primary QOL endpoint was clinically and statistically significant ($p < 0.0001$) with a mean SNOT-20 reduction from baseline to 24 weeks of -1.1 for the 112 patients with matching baseline and 24-week SNOT-20 data. Overall mean baseline SNOT-20 for the entire population ($n = 202$) was 2.1. The improvement in QOL from baseline to 2, 8, and 24 weeks was clinically significant (>0.8) at all time points relative to baseline. No significant differences in either mean baseline SNOT-20 score or QOL improvement were observed for the various subgroups: revisions or primary procedures, subjects with or without polyps, or subjects with or without irrigation.

Mean baseline LMK was 6.9 ± 3.6. Twenty-four–week CT scans were available for 110 patients, because many of the extended enrollment patients declined the optional 24-week follow-up and CT scan. The mean 24-week LMK was 2.5 ± 3.0, a statistically significant decline of -4.3 (95% CI, -4.9 to -3.6) from baseline ($p < 0.0001$).

TABLE 1. Mean SNOT-20 scores for all patients who completed SNOT-20 at baseline and the specified time point

	All subjects			Intrapatient change (matched pairs[a])			
Time point	Mean ± SD	n	95% CI	Change from baseline, mean ± SD	n	95% CI	*p*
Baseline	2.1 ± 0.9	202	2.0 to 2.2	—	—	—	
2 weeks	1.1 ± 0.8	190	1.0 to 1.2	−1.0 ± 0.9	189	−1.1 to −0.9	<0.0001
8 weeks	0.9 ± 0.8	178	0.8 to 1.0	−1.2 ± 1.0	177	−1.3 to −1.0	<0.0001
24 weeks	0.9 ± 0.8	113	0.8 to 1.1	−1.1 ± 1.0	112	−1.3 to −1.0	<0.0001

[a]Only includes subjects with both baseline and specified follow-up interval data.
CI = confidence interval; SD = standard deviation; SNOT-20 = 20-item Sino-Nasal Outcome Test.

TABLE 2. Relationship between the number of sinuses dilated and patient-rated overall procedural pain and return to normal activity

	Procedural pain			Return to normal activity (days)			
Number of sinuses dilated	Mean ± SD	n	95% CI	Mean ± SD	95% CI	Median	n
1	4.1 ± 2.6	38	3.2–5.0	2.4 ± 2.1	1.6–3.3	2.0	34
2	4.5 ± 2.6	62	3.9–5.2	2.3 ± 1.3	1.9–2.6	2.0	53
3	4.6 ± 2.6	18	3.3–5.9	1.6 ± 0.8	1.1–2.0	1.0	16
4	4.5 ± 2.0	64	4.0–5.0	2.1 ± 1.6	1.7–2.5	2.0	62
5	5.0 ± NA	1	NA	3.0 ± NA	NA	3.0	1
6	5.8 ± 1.4	10	4.8–6.8	2.6 (1.4)	1.5–3.7	3.0	9

CI = confidence interval; NA = not available; SD = standard deviation.

Secondary outcome endpoints

The mean overall procedure pain reported by the 198 patients completing the pain questionnaire was 4.5 ± 2.4 on a 0 to 10 scale. The procedure was rated as "highly tolerable" or "tolerable" by 82.3% of the patients, 14.7% rated the procedure as "somewhat tolerable" and 3.0% rated it as "not tolerable." There was no observed relationship between number of sinuses dilated or sinus type for those patients rating the procedure as not tolerable. The mean time to return to normal activities was 2.2 days postprocedure and the median time was 2.0 days. The majority of patients (69.9%) returned to normal activity within 2 days after the procedure. Table 2 shows the relationship between the number of sinuses dilated, procedure pain, and return to normal activity.

Of the 114 subjects surveyed at 24 weeks postprocedure, 77.2% would recommend the procedure to family and friends, 15.8% were not sure, and 7.0% would not recommend it to family and friends. Regarding whether they would have the procedure again, 72.8% answered "yes," 3.5% answered "no," and 23.7% answered "not sure."

Eighty-six percent of patients had no postoperative debridement. For the 13.8% of patients (26/188) who required a postoperative debridement, there were a total of 29 debridements with an average of 1.1 debridements per patient. For the entire study population, this results in an average of 0.15 debridements per patient. There were a total 6 revisions out of the 203 patients (3.0%) within the 24-week follow-up window. Revision procedures were conducted on previously balloon dilated sinuses. Two of the 6 revision procedures were conducted using BSD to address the frontal sinuses. Four revision procedures were conducted via traditional ESS for frontal (1 subject), maxillary (2 subjects), or both frontal and maxillary sinuses (1 subject). One BSD revision subject reported an improved outcome and 1 BSD revision subject was lost to follow-up. Three traditional ESS revision subjects had improved outcomes, and 1 worsened. Because the extended enrollment arm had an optional 24-week follow-up, the average follow-up time for all enrolled subjects was 18.1 weeks, with a median follow-up time of 21.6 weeks.

Ethmoid subgroup analysis

A total of 102 patients entered the study with an ethmoid LMK (eLMK) score greater than zero. Of these, 31 subjects did not have prior ESS, had no ethmoidectomy during their index procedure and had a 24-week CT available, creating the subgroup analysis dataset summarized in Table 3. The mean preoperative eLMK for this subgroup was 2.7 ± 1.2, and the 24-week postoperative eLMK was 0.7 ± 1.1.

TABLE 3. Ethmoid subgroup analysis of radiographic improvement and resolution

	eLMK			Radiographic resolution[a]	
Ethmoid cavity	Baseline, mean ± SD	24-week, mean ± SD	Change from baseline, mean ± SD (95% CI)	% Subjects (95% CI)	n
Overall ethmoid[b]	2.7 ± 1.2	0.7 ± 1.1	−1.9 ± 1.2 (−2.4 to −1.5)	64.5% (45.4% to 80.1%)	20/31
Anterior ethmoid[c]	1.8 ± 0.4	0.6 ± 0.9	−1.3 ± 0.9 (−1.6 to −0.9)	72.4% (52.8% to 87.3%)	21/29
Posterior ethmoid[c]	1.9 ± 0.5	0.3 ± 1.9	−1.6 ± 0.6 (−1.9 to −1.2)	81.3% (54.4% to 96.0%)	13/16

[a]The radiographic resolution for overall ethmoid reflects resolution of both anterior and posterior ethmoid sinuses. The radiographic resolution for anterior ethmoid or posterior ethmoid reflects radiographic resolution of anterior or posterior ethmoid sinuses, respectively.
[b]Maximum eLMK score for overall ethmoid is 8 (left and right anterior and posterior ethmoid).
[c]Maximum eLMK score for anterior or posterior ethmoid eLMK is 4 (left and right anterior or left and right posterior).
CI = confidence interval; eLMK = ethmoid Lund-Mackay score; SD = standard deviation.

Complete radiographic resolution of ethmoid disease (eLMK = 0) was observed in 64.5% (20/31; 95% CI, 45.4%-80.1%) of subjects. Radiographic improvement of ethmoid LMK score was observed for 87.1% (27/31) of subjects in this group, whereas 12.9% (4/31) remained the same and none (0.0%) worsened. QOL (SNOT-20) improvement for this subgroup was clinically and statistically significant ($p < 0.0001$) at all follow-up intervals, with a mean change in SNOT-20 of -1.0 ± 0.9; 95% CI, -1.4 to -0.7) at 24 weeks.

Of those patients in the subgroup with anterior ethmoid disease, the anterior radiographic resolution rate was 72.4%. Of those with posterior ethmoid disease, the posterior radiographic resolution rate was 81.3%. There were 37 patients entering the study that did not have radiographic ethmoid disease at baseline, did not have prior ESS, and had a 24-week CT available for analysis. Of these patients, 10.8% (4/37) were observed to have an increase in mean eLMK score (2.3) during the follow-up period. The SNOT-20 improvement (-1.6) in this small number of patients with increased eLMK scores did not appear to be different ($p = 0.686$) than the SNOT-20 improvement (-1.3) for those patients without eLMK increase.

Discussion

In this multicenter prospective study, we have demonstrated that office-based transnasal balloon dilation of maxillary, frontal, and sphenoid sinuses is safe and effective for appropriately selected patients. A validated QOL instrument demonstrated statistically and clinically significant improvement and the radiographic outcome showed statistically significant decline in radiographic disease burden.

Given the relatively large size of the study, we can conclude that sinus dilation under local anesthesia is safe after proper training. The overall technical success rate of 93.3% is acceptable given the potential advantage of the office procedure and comparable to the 96.9% rate of technical success reported for operating room (OR)-based BSD.[12] It is important to point out that all of the investigators had substantial experience with these instruments in an OR setting prior to enrollment in this study. Such experience is critical in ensuring a safe and successful outcome, and we would not advocate the office setting as the location to initially use balloon dilation tools. Precise manipulation of the instruments and avoidance of the nonanesthetized nasal areas are imperative both for procedure tolerability and for minimizing bleeding.

There are only a few prior reports in the literature of office-based BSD. Cutler et al.[13] reported on 19 patients undergoing maxillary ostial dilation using a canine fossa approach in the office setting under local anesthesia; 94% of the maxillary ostia were determined to be patent at 3 months postoperation, and maxillary mucosal thickening was significantly reduced. SNOT-20 scores showed statistical and clinically significant reduction out to 12 months. The broad clinical applicability is unfortunately limited by the instrumentation used, which can only dilate maxillary sinuses. Patients with frontal and sphenoid disease were excluded from the study. Eloy et al.[14] reported retrospectively on 5 patients who had office-based dilation of a previously operated and stenosed frontal sinusotomy using transnasal balloon dilation instrumentation. All 5 patients were reported to be "asymptomatic" at a mean follow-up of 5 months with patent drainage pathway. Although Eloy et al.'s[14] work is a promising preliminary report, the study is limited by the small sample and the lack of a validated QOL instrument upon which to base patient symptom outcomes. Luong et al.[15] also provides a limited retrospective report of 6 patients undergoing office-based dilation for postoperative frontal sinus ostium stenosis using either a lacrimal dilation catheter or a sinus dilation catheter. Endoscopic patency was confirmed for all patients at an average follow-up of 6 months, including 1 sinus that required a second dilation during the follow-up. The patient-reported outcomes are limited by lack of a baseline questionnaire and use of a nonvalidated survey. A recent report including 37 patients with CRS demonstrated feasibility of in-office BSD for all sinuses, technical success, procedure tolerability, and clinically and statistically improvement in patient symptoms.[16] In this study, we enrolled over 200 patients with disease in all of the peripheral sinuses, and used a validated QOL instrument and an objective radiographic measure of disease burden change. There was no observed correlation between the number of sinuses treated and subject-reported procedural discomfort, further corroborating the practicability of a procedure for all peripheral sinuses.

Office-based sinus dilation was shown to be well-tolerated by the majority of subjects. Return to normal activities was typically observed within 2 days of the procedure.

Several patients with ethmoid disease were enrolled in this study, because the presence of disease in the ethmoid cavity was not an exclusion criterion. Prior to this study, several investigators had anecdotally noted ethmoid disease resolution in some patients when peripheral sinuses were dilated and the ethmoid cavity left "untreated" (ie, no ethmoidectomy). There is limited support for this concept in the literature. Chan et al.[17] studied 5 patients with chronic frontal sinusitis who had failed medical management and also presented with ipsilateral anterior ethmoid sinusitis. After balloon dilation of the frontal stenoses without ethmoidectomy, all patients showed complete radiographic clearing of *both* the dilated frontal sinus and the anterior ethmoid. Stankiewicz et al.[18] demonstrated that patients with both maxillary and anterior ethmoid disease could exhibit statistically and clinically significant improvement in QOL with just maxillary dilation. We are unaware of any studies that have investigated whether posterior ethmoid disease requires an ethmoidectomy for effective treatment.

We wish to be clear that this study was not designed nor powered to allow conclusions about ethmoid disease resolution without ethmoidectomy. However, we present our findings as provocative observational data in the hopes

that it spurs debate and future study. In this study, we found that a surprising number of patients showed improvement in ethmoid disease without ethmoidectomy, and many showed complete radiographic resolution. These patients also showed QOL improvement similar to the entire study population. What we cannot tell from this study is whether these patients are at higher risk for recurrence of disease in the future.

We do not know the reason for the increased eLMK score in the 10.8% patients who had clear ethmoids entering the study, but suspect it indicates that there is an increased tendency toward inflammation in this CRS patient population. Of note, the SNOT-20 improvement in this small number of patients with increased eLMK scores was not worse than those patients without eLMK increase. Improvement was greater in this small group but the limited sample size precludes conclusion, as the study was not designed to address this specific question. Overall, it appears that the small number of patients that developed ethmoid disease during the study showed improvements in QOL similar to the patients that did not develop ethmoid disease. It cannot be ruled out that balloon dilation could contribute to iatrogenic ethmoid disease by moving the uncinate and/or ethmoid bulla in a fashion that obstructs ethmoid outflow. Given that 74.9% of patients had maxillaries dilated, this seems unlikely. The uncinate is mobilized anterolaterally, which also suggests that structures are being moved away from, rather than toward, ethmoid outflow paths.

This study has several limitations. Although all patients met the generally accepted definition of CRS and were refractory to medical therapy, the specific regime of preoperative and postoperative medical therapy was not controlled across the sites. Rather, we followed the model similar to the American Rhinologic Society Study Group,[11] in which investigators customized the medical therapy to the particular patient's disease. The study design does not allow us to eliminate postoperative medical therapy optimization as a contributor to the improvement in patient QOL or other outcome measures including ethmoid improvement, although the medically refractory nature of the patient population lessens this potentially confounding factor. An additional limitation to the study includes lack of standardization of the timing of the preoperative CT scan with respect to medical therapy failure.

The study is not a comparative study, so we cannot make any definitive conclusions regarding how the patient outcomes compare to an OR-based balloon dilation or "traditional" ESS procedure. The preoperative SNOT-20 scores are comparable to prior reports of OR-based balloon dilation[12] and ESS,[19] suggesting that the patient population in this study suffered from a similar disease burden as prior studied populations. The preoperative to postoperative SNOT-20 change is also similar to prior OR-based balloon dilation and ESS studies,[12,20] suggesting similar levels of patient symptomatic resolution. Given the fact that most of the investigators were performing their first office-based cases within the data collection frame of this study, these results are encouraging. A comparison of OR-based ESS or continued medical management to office-based balloon dilation are potential future areas of study.

Follow-up was through 24 weeks only, which limits the conclusions that can be made regarding expectation for maintenance of patient improvement over longer time periods. However, Soler and Smith[21] and Weiss et al.[4] both showed that QOL results are stable from 6 months out to at least 2 years following ESS or BSD, respectively.

Conclusion

This prospective multicenter study of office-based transnasal BSD of maxillary, frontal, and sphenoid sinuses demonstrated improvement in QOL and radiographic outcome at 24-week follow-up. In addition, a high level of technical success, patient-reported tolerability, and lack of device-related adverse events shows that office-based BSD under local anesthesia is a safe, effective, and well-tolerated option for patients whose prescribed surgical intervention does not necessitate general anesthesia.

Acknowledgments

We acknowledge Acclarent for providing the financial and logistic sponsorship for the study, as well as data monitoring, data analysis, and assistance in drafting the manuscript.

ORIOS2 Study Investigators: Neil Brown, MD, La Crosse Clinic, La Crosse, WI; Brian Heaberlin, MD, HIMG Regional Medical Center, Huntington, WV; Edward Hepworth, MD, Associates of Otolaryngology, Denver, CO; Jacob Johnson, MD, San Francisco Otolaryngology, San Francisco, CA; Boris Karanfilov, MD, Ohio Sinus Institute, Dublin, OH; Rom Karin, MD, ENT Clinic of Los Gatos, Los Gatos, CA; David Keschner, MD, JD, Southern California Permanente Medical Group, Anaheim, CA; Steven Levine, MD, ENT and Allergy Associates, Trumbull, CT; Raza Pasha, MD, Pasha Snoring & Sinus Center, Houston, TX; Alan Shikani, MD, FACS, Maryland Nose and Sinus Center, Baltimore, MD; Ashley Sikand, MD, Ear, Nose & Throat Consultants of Nevada, Las Vegas, NV; Michael Sillers, MD, Alabama Nasal and Sinus Center, Birmingham, AL; Stacey Silvers, MD, Madison ENT & Facial Plastic Surgery, New York, NY; and Richard Strabbing, DO, Spectrum Health Medical Group, Holland, MI.

References

1. Pleis JR, Ward BW, Lucas JW. Summary health statistics for U.S. adults: National Health Interview Survey, 2009. *Vital Health Stat 10*. 2010;(249):1–207.
2. Lal D, Scianna JM, Stankiewicz JA. Efficacy of targeted medical therapy in chronic rhinosinusitis, and predictors of failure. *Am J Rhinol Allergy*. 2009;23:396–400.
3. Millennium Research Group. *US Markets for ENT and Bronchoscopy 2008*. Report rpus30eb08. Toronto, ON, Canada: Millennium Research Group; 2008.

4. Weiss RL, Church CA, Kuhn FA, Levine HL, Sillers MJ, Vaughan WC. Long-term outcome analysis of balloon catheter sinusotomy: two-year follow-up. *Otolaryngol Head Neck Surg*. 2008;139:S38–S46.
5. Plaza G, Eisenberg G, Montojo J, Onrubia T, Urbasos M, O'Connor C. Balloon dilation of the frontal recess: a randomized clinical trial. *Ann Otol Rhinol Laryngol*. 2011;120:511–518.
6. Levine HL, Sertich AP 2nd, Hoisington DR, Weiss RL, Pritikin J; PatiENT Registry Study Group. Multicenter registry of balloon catheter sinusotomy outcomes for 1036 patients. *Ann Otol Rhinol Laryngol*. 2008;117:263–270.
7. Rosenfeld RM, Andes D, Bhattacharyya N, et al. Clinical practice guideline: adult sinusitis. *Otolaryngol Head Neck Surg*. 2007;137:S1-S31.
8. Johansen VL, Illum P, Kristensen S, Winther L, Vang Petersen S, Synnerstad B. The effect of budesonide (Rhinocort®) in the treatment of small and medium-sized nasal polyps. *Clin Otolaryngol Allied Sci*. 1993;18:524–527.
9. Lund VJ, Mackay IS. Staging in rhinosinusitis. *Rhinology*. 1993;31:183–184.
10. Piccirillo JF, Merritt MG, Richards ML. Psychometric and clinimetric validity of the 20-item Sino-Nasal Outcome Test (SNOT-20). *Otolaryngol Head Neck Surg*. 2002;126:41–47.
11. Smith TL, Kern RC, Palmer JN, et al. Medical therapy vs surgery for chronic rhinosinusitis: a prospective, multi-institutional study. *Int Forum Allergy Rhinol*. 2011;1:235–241.
12. 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*. 2007;137:10–20.
13. 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*. 2011;1:460–465.
14. Eloy JA, Friedel ME, Eloy JD, Govindaraj S, Folbe AJ. In-office balloon dilation of the failed frontal sinusotomy. *Otolaryngol Head Neck Surg*. 2012;146:320–322.
15. Luong A, Batra PS, Fakhri S, Citardi MJ. Balloon catheter dilatation for frontal ostium stenosis in the office setting. *Am J Rhinol*. 2008;22:621–624.
16. Albritton FD 4th, Casiano RR, Sillers MJ. Feasibility of in-office endoscopic sinus surgery with balloon sinus dilation. *Am J Rhinol Allergy*. 2012;26:243–248.
17. Chan Y, Melroy CT, Kuhn FA. Is anterior ethmoid disease really responsible for chronic frontal sinusitis? Presented at the Annual Meeting of the American Rhinologic Society Annual Meeting, Chicago, IL, September 2008.
18. Stankiewicz J, Tami T, Truitt T, Atkins J, Liepert D, Winegar B. Transantral, endoscopically guided balloon dilatation of the ostiomeatal complex for chronic rhinosinusitis under local anesthesia. *Am J Rhinol Allergy*. 2009;23:321–327.
19. Jones ML, Piccirillo JF, Haiduk A, Thawley SE. Functional endoscopic sinus surgery: do ratings of appropriateness predict patient outcomes? *Am J Rhinol*. 1998;12:249–255.
20. Moghaddasi H, Taheri MS, Jalali AH, Shakiba M. Correlation of Lund-Mackay and SNOT-20 before and after functional endoscopic sinus surgery (FESS): does the baseline data predict the response rate? *Iran J Radiol*. 2009;6:207–214.
21. Soler ZM, Smith TL. Quality-of-life outcomes after endoscopic sinus surgery: how long is long enough? *Otolaryngol Head Neck Surg*. 2010;143:621–625.