Impact of Perioperative Systemic Steroids on Surgical Outcomes in Patients With Chronic Rhinosinusitis With Polyposis: Evaluation With the Novel Perioperative Sinus Endoscopy (POSE) Scoring System

Erin D. Wright, MDCM, MEd; Sumit Agrawal, MD

Objectives/Hypothesis: The objective of this randomized, double-blind, placebo-controlled study was to assess the effect of perioperative systemic steroids on subjective and objective surgical outcomes for patients undergoing endoscopic sinus surgery (ESS) for chronic rhinosinusitis with polyposis (CRSwP). The secondary objective was to begin validation of the newly developed Perioperative Sinus Endoscopy (POSE) scoring system.

Methods: Patients who had failed maximal medical therapy and were scheduled to undergo ESS were eligible for the study. Participants were randomized to receive either 30 mg of prednisone or placebo for 5 days preoperatively and 9 days postoperatively. Operative and baseline clinical data were collected using the Lund-McKay staging system including its Sinus Symptom Questionnaire as well as additional data regarding mucosal health, the technical difficulty of surgery, and endoscopic data using the Lund-Kennedy Endoscopic Score (LKES) and POSE scale. Data were also collected at 2 weeks, 1 month, 3 months, and 6 months postoperatively. A sample size of 24 was calculated to detect a clinically relevant difference between groups of 40%. Routine statistical comparisons were performed as were repeated measures analysis of variance with Bonferroni adjustment because of the multiple comparisons performed. To address the secondary objective, data were also collected at all postoperative time points using the POSE instrument, which was designed with the intention of enhancing face validity and responsiveness to change. Comparisons were performed between the POSE and LKES, including assessment of sensitivity to change, correlation between the two scales, and correlation with symptom scores.

Results: Twenty-six patients participated in the study. Operative data demonstrated a significantly higher percentage of severely inflamed sinonasal mucosa in patients not pretreated with systemic steroids, which was associated with technically more difficult surgery in the estimation of the operating surgeon. In terms of postoperative symptoms, there was no difference between treatment groups, with both placebo and prednisone significantly improved over baseline up to 4 weeks postoperatively. Endoscopic assessment of patients postoperatively demonstrated a treatment effect (P < .05), with clinically healthier cavities seen in patients treated with prednisone up to 6 months postoperatively as compared with baseline (P < .001), although the strongest effect was seen at the 2-week time point. In comparing the two endoscopic scales, the POSE and LKES correlated highly (R > 0.70; P < .001) both in terms of absolute score and change in score. There is some evidence that the POSE score may be more sensitive to change than the LKES, and the POSE scores
INTRODUCTION

Chronic rhinosinusitis (CRS) is a common problem that exacts a high cost in terms of direct health care as well as lost productivity. The common pathophysiological denominator for virtually all forms of CRS is inflammation, for which extensive pharmacotherapy is available including topical corticosteroids, antibiotics, saline irrigations, and systemic steroids. Unfortunately, not all patients are cured or achieve control of their symptoms even with maximal pharmacotherapy. In these patients who have failed medical management, endoscopic sinus surgery (ESS) has been demonstrated and is generally accepted to provide improved relief of symptoms and better quality of life. It is a commonly performed procedure, with an estimated 250,000 procedures performed annually in the United States.

Although there is some controversy as to the best or most appropriate surgical technique for treating patients with CRS with polyposis (CRSwP), most surgeons will recommend that these patients undergo polypectomy, complete ethmoidectomy, and middle meatal antrostomy, with or without frontal sinusotomy or sphenoidotomy. However, there is significant variability and a lack of standardization or guidelines with respect to the preparation and perioperative pharmacotherapy regimen and management for patients undergoing ESS for CRSwP. In fact, except for review papers outlining expert opinion and some evidence supporting the use of topical steroids postoperatively, there is little evidence to guide the perioperative therapy for this patient population.

In particular, some surgeons advocate the use of preoperative systemic steroids, citing such advantages as facilitation of the surgical procedure by reducing edema, polyp load, and bleeding. In contrast, a national survey of Canadian otolaryngologists revealed that a significant percentage of sinus surgeons did not routinely use perioperative systemic steroids. In addition, anecdotal experience suggests that these two cited papers are reflective of the variability in clinical practice present throughout North America. The theoretic advantages of perioperative steroids often cited include reduced edema and scarring postoperatively as well as suppression of the intrinsic inflammatory disease to permit better healing and better outcomes. Relevant to this discussion is the fact that systemic steroids have been well described to have a litany of potential side effects, ranging from nuisance short-term problems such as mood disturbance and fluid retention, to moderate effects such as gastric irritation, to devastating side effects such as osteonecrosis of the femoral head.

Therefore, given that some surgeons advocate the use of perioperative systemic steroids whereas others do not and given that the current evidence on this question is limited and given that there are hundreds of thousands of ESS procedures performed each year and given that systemic steroids have significant potential side effects, it is the primary objective of this study to assess the value of perioperative systemic steroids in patients undergoing ESS for the treatment of CRSwP. The study design developed to assess surgical outcomes is randomized, double-blind, and placebo-controlled and seeks to assess specific surgical outcomes at the time of surgery as well as subjective and objective outcomes in the short and intermediate postoperative period.

Objectives of the Study

The primary objective of the study is to assess the effect of perioperative systemic corticosteroids on both subjective and objective outcomes in patients undergoing ESS for treatment of CRSwP. The primary measure of subjective change is the Sinus Symptom Questionnaire (SSQ) from the Lund-McKay staging system. The measure of objective change is the Lund-Kennedy Endoscopy Scale (LKES). Consequently, the primary objective of the study can be stated as three specific subobjectives, as follow:

Objective 1A. To assess the effect of perioperative prednisone versus placebo with respect to operational parameters of the technical aspects of surgery (e.g., ease of surgery, blood loss, operative time).

Objective 1B. To assess the effect of perioperative prednisone versus placebo with respect to changes in the seven subscales of the SSQ and the SSQ summation score.

Objective 1C. To assess the effect of perioperative prednisone versus placebo with respect to changes in the total LKES.

The secondary objective of the study is to compare the newly developed Perioperative Sinus Endoscopy (POSE) score with the LKES. The POSE instrument was developed with the intent of creating a refined, specific tool to endoscopically assess the sinus cavities of patients who have undergone ESS. Thus, to begin to validate it and to determine whether the new scale offers any measurable advantages over the older, more-established scale, four specific subobjectives are delineated, as follow:

Specific objective 2A. To compare the POSE score with the LKES in terms of sensitivity to change during ESS postoperative follow-up in patients with CRSwP.

Specific objective 2B. To determine the degree of correlation between change in POSE score and change in symptom severity, both as measured using the Lund-McKay SSQ and the Chronic Sinusitis Survey (CSS).

Specific objective 2C. To estimate the levels of correlation between the POSE scale and the LKES and the
levels of correlation between changes in the POSE and the LKES.

**Specific objective 2D.** To estimate the predictive power of the POSE score used 2 weeks post-ESS as a tool to predict long-term response to ESS in patients with CRSwP.

**METHODS**

**Patient Selection**

The patient population chosen for study was that with CRSwP. This is the patient population within the CRS population that tends to be the most recalcitrant with respect to the recurrence of both objective and subjective findings postoperatively. It is also the population in which some surgeons are likely to use perioperative systemic steroids.\(^7\,\text{11}\)

**Diagnostic Criteria**

Consistent with the most recent definitions recommended for clinical research into rhinosinusitis,\(^15\) the study population included patients with symptoms of mucopurulent nasal drainage, nasal obstruction, and decreased sense of smell for greater than 12 weeks duration. Patients all underwent diagnostic nasal endoscopy to confirm the presence of nasal polyposis bilaterally as well as computed tomography (CT) scanning to confirm bilateral mucooeal disease. No further subclassification beyond CRSwP was performed, consistent with the current definitions and guidelines for research regarding patients with rhinosinusitis.\(^15\)

**Inclusion Criteria**

Adult patients (over 18 yr of age) scheduled to undergo ESS for treatment of their disease were offered the opportunity to participate in the study. There was no upper age limit. To become candidates for ESS, the patient either had to have failed or refused maximal medical therapy. Maximal medical therapy for patients with CRSwP included prolonged trials of topical therapy for more than 3 months. Topical therapy was defined as intranasal steroids given twice daily and saline irrigations. Antibiotics in the form of a 4 to 6 week course were used as appropriate as based on the endoscopic findings and endoscopically guided culture results rather than on an empiric basis. All patients were offered a tapering trial of systemic steroids of at least 2 weeks prior to being deemed a surgical candidate. Failure of the course of systemic steroids was defined as recurrence or persistence of symptoms as well as recurrence and persistence of polyps and inflammation within 2 months of the steroid course.

**Exclusion Criteria**

Patients with immunocompromised status and mucociliary disorders were excluded. In addition, patients with allergic fungal sinusitis (AFS) were excluded from the study. This was done preoperatively based on the classic endoscopic findings of allergic mucin and the presence of classic CT scan findings. Patients who were equivocal (e.g., double-density sign on CT but no allergic mucin on diagnostic nasal endoscopy) were allowed to proceed to surgery, where histopathologic analysis was performed. Presence of classic allergic mucin with Charcot-Leyden crystals and fungal hyphae constituted the diagnosis of AFS, and the patient was not included in the study population.

**Experimental Design**

To assess the impact of perioperative systemic steroids on surgical outcomes in patients with CRSwP, a randomized, double-blind, placebo-controlled study was designed. Once patients were determined to meet the inclusion criteria for the study, they were randomized to receive either placebo or systemic steroids for 5 days preoperatively and 9 days postoperatively. The dose used was 30 mg taken as the entire daily dose in the morning. Because there is no solid evidence on which to base this choice of dose, anecdotal clinical experience of the author was used to inform this choice. The moderate dose chosen (30 mg) for this study was believed to be sufficient for effective clinical activity and to mitigate the potential undesirable short-term side effects associated with higher doses (e.g., 50–60 mg). At the time of the experimental design, the current view of systemic steroid therapy held that 2 weeks or less duration of therapy did not require tapering at the end of the course of treatment, and, as such, there was no taper built into the regimen.

Once a date for surgery was set, patients were mailed their medication along with clear instructions regarding dosing. Active medication and placebo were externally identical in terms of capsule preparation. Patients continued the medication after surgery for the prescribed time. Compliance was confirmed at the second postoperative visit, at which time patients should have completed the course of therapy.

**Surgical Technique**

ESS was performed using the Messerklinger technique as described by Kennedy.\(^16\) Mucosal preservation and preservation of normal structures was attempted in all cases. The extent of surgery performed and the specific sinuses that were addressed was determined by the disease present in each patient and was thus individualized for each patient. Packing materials were used as necessary for hemostasis or stenting and generally consisted of Merocel (Medtronic-Xomed Canada, Mississauga, ON) sponges when used. All patients were placed on saline sprays postoperatively as well as postoperative antibiotics for a period of 2 weeks. They resumed their topical intranasal steroid sprays 1 day after any packing or stenting material was removed.

**Data Collection Points**

Patients were routinely seen on postoperative days 2 to 4 for removal of the packing or stenting materials. They were then seen at 2 weeks postoperatively for endoscopic inspection and debridement of the ethmoid cavities. This formed the first postoperative data collection point. Further follow-up in the form of office visits and debridoements was tailored to the needs of each individual patient. However, all patients were seen, and had data collected, at 1 month postoperatively as well as at 3 months and 6 months. Thus, in addition to the baseline data on the day of surgery, there were four additional data points (2 wk, 1, 3, and 6 mo) representing both short- and intermediate-term outcomes. Although data collection could continue for those patients who required ongoing follow-up, it was determined that the formal follow-up required to complete the study would be limited to 6 months. The reasoning for this was twofold. First and foremost, it was hypothesized that there is no a priori expectation that the intervention of perioperative systemic steroids would have a clinically meaningful impact beyond 3 months. Nevertheless, to account for this possibility, the data collection was extended beyond this point to the 6-month follow-up visit. Also, in this same thread of reasoning, the further the patient was from surgery, the more the confounding factors that could be introduced into the equation. Second, it was unreasonable to expect that, in the unlikely event that if a patient was doing exceedingly well with no evidence of recurrent disease, he or she would continue to come for follow-up for study purposes only. Losing those patients who were doing well from the study, and consequently from the ongoing analysis, could potentially introduce negative bias.
Sample Size

In determining the sample size required for the study, several assumptions needed to be made. Given the two-treatment, parallel design of the study, the statistical power was assumed to be 80%, and the needed significance level (2-tailed alpha error) was assumed to be 5%. Based on data collected by the same author for a previous unpublished study involving a similar study population, a mean of 8.02 and an SD of 2.62 for the Lund-Kennedy endoscopic grading system was used for calculation. For the treatment impact to be clinically relevant, a sample difference of 40% was assumed (difference between the means of the two groups = 3.2). With use of the Harvard method, a sample size of 24 was calculated (http://hedwig.mgh.harvard.edu/sample_size/quant Measure/para_quant.html).

Ethics Approval

The Research Ethics Board (REB) for Health Sciences Research Involving Human Subjects of the University of Western Ontario reviewed the experimental design and protocol as well as the letter of information and the consent form. Full approval of the board was granted under protocol number 10176. To complete the data collection, after all patients had been enrolled in the study, a 6-month extension was requested from the REB and was granted in December of 2005. All patients received a detailed letter of information outlining the experimental protocol, and all patients signed a consent form prior to entering the study.

Data Collection

The overall approach to data collection for outcomes in this study of the impact of perioperative systemic steroids was tripartite. Data were first collected regarding the surgery itself and its relative difficulty including the health and state of the sinonasal mucosa. In terms of postoperative data, two additional primary outcomes were identified, namely, subjective assessment of the impact of the disease on the patient (i.e., symptoms) as well as objective data in the form of nasal endoscopy.

Operative Data

The data collected for this portion of the study was based on the modified Lund-Mackay staging system. All patients entering the study were assigned a unique identification number. Their hospital medical record number was linked to this number for reference as needed. Data collected at the time of surgery included the incidence of surgical- or anesthetic-related complications. The nature of the surgery, either primary or revision, was also noted. The date of surgery and the presence of an assistant (e.g., resident) were also recorded, as was the history of asthma, atopy, or aspirin sensitivity.

The anesthetic technique, duration of the procedure, and estimated blood loss were all recorded. These were taken in a standardized fashion from the electronic nursing record. The author's institution routinely records the time for "surgery start" and "surgery end." Also noted at the time of surgery was the health of the nasal and turbinate mucosa. A 3-point scale (healthy = 1, inflamed/erythematous = 2, severely inflamed/friable = 3) was used for this measurement. Finally, the difficulty of the surgery was subjectively estimated by the surgeon, again using a 3-point scale (1 = easy, 3 = very challenging), which factored in issues such as bleeding and ability to maintain visualization.

Radiologic staging data based on the modified Lund-Mackay system was recorded, as was the presence of anatomic variants that may have had an impact on the surgery or the disease. In addition, the planned and actual surgery score were noted, again based on the modified Lund-Mackay system.

Subjective Outcomes

In choosing a subjective grading scheme, it was decided to use the historically reliable, disease-specific Lund-Mackay SSQ. The reasoning for this choice was reproducibility, reliability, and demonstrated validity. In addition, the results are easy to interpret and record with minimal burden to the study participant. It was also believed to be useful for assessing disease activity over time and thought to be responsive to change. Also, there was available historical data for sample size calculation as well as maintenance of consistency in the overall data collection, with the Lund-Mackay system being used for operative data and preoperative disease severity estimation. Also, in keeping with the current recommendations to assess both specific symptoms and global severity, this scale permits both.

Thus, a visual analogue scale (VAS) that measures from 0 (symptom not present) to 10 (extremely severe) was used to assess the six symptoms of nasal blockage/congestion, headache, facial pain, olfactory loss, nasal discharge/post nasal drip, and sneezing. A single, global assessment is also measured with the VAS, and patients were also asked to rank the three most troublesome symptoms.

To assess the impact of the systemic steroids on the intermediate length control of the disease process, it was elected to use the CSS. This instrument is a validated, often-used, duration-based monitor of sinusitis-specific outcomes that measures symptom control and the need for medication over the previous 8 weeks to provide an estimate of disease activity during that time. These data were collected at the 3 and 6-month follow-up visits as a measure of disease activity. It was the intent of the study to examine the impact of the intervention on the disease process and disease-specific outcomes, and so no general health measures were incorporated into the protocol.

Objective Outcomes

Nasal endoscopy was included as the single most important outcome measure of disease activity in this study. The objective nature of the assessment with direct inspection of the sinus cavities helped to avoid the potential unreliability of patient symptoms as an estimate of the disease, particularly in the early stages of recurrence or persistence postsurgery. Nasal endoscopy is an excellent way to assess disease presence and severity, and several scales exist to record and score the findings. The Lund-Kennedy nasal endoscopy scoring system was included in the modification of the Lund-McKay staging system proposed by Kennedy and Lund and is a simple, easily applied, and reproducible system that assesses five specific findings in the ethmoid cavities.

In the interest of enhancing face validity, accuracy, and responsiveness to change, a new endoscopic grading system for perioperative sinonasal endoscopy was also developed for use in this study. In designing the scoring system, factors routinely noted on postoperative endoscopy as well as factors thought to be important in estimating control of the disease were included. The intent was also to try to make it intuitive to complete, incorporating information in much the same way it is mentally stored in the clinician’s mind’s eye.

This new POSE scale (Fig. 1) includes an assessment of the middle meatus and middle turbinate, which form the gateway to the rest of the sinus cavities. The presence of synechiae between the middle turbinate and the lateral nasal wall or lateralization of the middle turbinate are noted, with the presence of either being scored as 1 and the absence scored as 0.

Because virtually all patients undergoing ESS will have the middle meatal natural ostium of the maxillary sinus addressed at the time of surgery, this too was incorporated into the scoring scheme. Issues that could indicate activity of inflammatory disease such as stenosis and the presence of secretions or edema were
The table below provides the Perioperative Sinus Endoscopy (POSE) score for various anatomical locations:

<table>
<thead>
<tr>
<th>Middle Turbinates</th>
<th>Right</th>
<th>Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Synchiae/lateralized</td>
<td></td>
<td>1-2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Middle Meatus/MMA</th>
<th>Right</th>
<th>Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthy</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Narrowing/Closure</td>
<td>1-2</td>
<td></td>
</tr>
<tr>
<td>Maxillary Sinus Contents</td>
<td>1-2</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ethmoid Cavity</th>
<th>Right</th>
<th>Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthy</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Crusting</td>
<td>1-2</td>
<td></td>
</tr>
<tr>
<td>Mucosal Edema</td>
<td>1-2</td>
<td></td>
</tr>
<tr>
<td>Polypoid Change</td>
<td>1-2</td>
<td></td>
</tr>
<tr>
<td>Polyposis</td>
<td>1-2</td>
<td></td>
</tr>
<tr>
<td>Secretions</td>
<td>1-2</td>
<td></td>
</tr>
<tr>
<td>Total (16)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Secondary Sinuses**

<table>
<thead>
<tr>
<th>Frontal Recess/Sinus</th>
<th>0-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sphenoid Sinus</td>
<td>0-2</td>
</tr>
</tbody>
</table>

**Overall Total**

<table>
<thead>
<tr>
<th>16 18F</th>
<th>18S 20</th>
</tr>
</thead>
</table>

The POS-40 scale is divided into three categories: mucosal edema, polypoid change, and polyposis. For mucosal edema, a score of 0 is assigned for absent, 1 when the middle meatus but not to the inferior turbinates, and 2 when beyond the upper border of the inferior turbinates. As part of this scheme, it is inferred that severe polyoid change will involve mucosal swelling that extends up to but not beyond the middle turbinate. By splitting up the mucosal swelling assessments into three sequential categories, namely, mucosal edema, polyoid change, and polyposis, it was hoped to increase the sensitivity of the scoring system. The final item in the ethmoid cavity score is the presence of secretions, which is scored as absent (0), thin or mucoid (1), and purulent/allergic (2).

In an effort to account for differing disease severity and extent of surgery performed, the new endoscopy scoring system included items recording the state of the frontal recess/sinus and the sphenoid sinus in the event that had been opened. The frontal recess/sinus is scored as patent/healthy (0), narrowed/edema present (1), or obstructed/inflamed/severely inflamed (2). Similarly, the sphenoid sinus is scored as patent/healthy (0), edematous/narrowed (1), and obstructed/inflamed/severely inflamed (2).

Given the potentially differing denominators for this scoring system, it was decided to generate two potential scores for each patient. The correlation matrix was calculated, and an adjustment was undertaken to set $P < .001$ for statistical significance because of the multiple comparisons being performed. For correlations, the Pearson $R$ was calculated, and an a priori decision was made to categorize $R < 0.49$ as a weak correlation; $0.50 < R < 0.69$ as a moderate correlation; and $R \geq 0.70$ as strongly correlated.

### RESULTS

**Effect of Perioperative Steroids on Surgical Outcomes in ESS**

Steroid effect on operative parameters. As can be seen in Table I, there were no significant differences between the study groups with respect to radiologic stage and total procedures planned. However, it is interesting to note that in the placebo group, the number of procedures

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**Statistical Analysis**

All data were collected and entered into a standard statistical package database (SPSS v12.0, Chicago, IL). Standard demographic summaries were generated, and routine comparisons were made using both univariate (paired Student $t$ test) and multivariate (repeated measures analysis of variance [RM-ANOVA]) analysis. In addition, for the within group comparisons at multiple time points versus baseline, a Bonferroni adjustment was undertaken to set $P < .001$ for statistical significance because of the multiple comparisons being performed. For correlations, the Pearson $R$ was calculated, and an a priori decision was made to categorize $R < 0.49$ as a weak correlation; $0.50 < R < 0.69$ as a moderate correlation; and $R \geq 0.70$ as strongly correlated.

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performed (i.e., the number of sinuses opened surgically) was actually slightly lower than planned, an effect not observed with the prednisone group. As noted by the operating surgeon, this difference was not caused by the absence of disease in the unopened sinuses but rather was limited by technical issues primarily related to visualization/bleeding. However, the difference between the groups was not statistically significant.

As outlined in the legend for Table I, an a priori decision was made to consider a 40% difference between groups as clinically significant. Thus, with respect to the health of the sinonasal mucosa as assessed at the time of surgery, there was a clinically significant difference between the groups, with the placebo group having a much higher incidence of severely inflamed mucosa as compared with the prednisone group. The degree of difficulty of the surgery assessed by the surgeon also showed a significantly higher percentage of patients in the placebo group having a surgery rated as being of more than average difficulty as compared with the prednisone group. The other objective parameters assessed including operative duration and blood loss showed no difference between groups.

**Steroid effect on subjective outcomes.** As can be seen in Table II, the symptom of nasal obstruction was significantly improved across both groups at virtually all time points. Similar findings are noted for the overall SSQ score for all domains up to 4 weeks, after which the symptomatic effect of surgery begins to wane. Although there is a trend toward lower scores (less symptoms) to 6 months, the differences are not statistically significant. The symptom of reduced olfaction showed a statistically significant difference between placebo and prednisone groups at 2 weeks (prednisone group better, \( P < .001 \)), with a significant trend to 4 weeks but no difference thereafter. Overall, there was no

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**TABLE I.**
Baseline Characteristics, Comparing Treatment vs. Placebo Groups.

<table>
<thead>
<tr>
<th></th>
<th>Prednisone Group</th>
<th>Placebo Group</th>
<th>Intergroup Difference</th>
<th>Placebo/Prednisone* (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>11</td>
<td>15</td>
<td>-4</td>
<td>136</td>
</tr>
<tr>
<td>Dropouts</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>n/m</td>
</tr>
<tr>
<td>Baseline clinical health</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nasal blockage score (0–10)</td>
<td>8.3</td>
<td>8.2</td>
<td>-0.1</td>
<td>98</td>
</tr>
<tr>
<td>Headache (0–10)</td>
<td>2.7</td>
<td>2.2</td>
<td>-0.5</td>
<td>80</td>
</tr>
<tr>
<td>Facial pain score (0–10)</td>
<td>2.0</td>
<td>1.8</td>
<td>-0.3</td>
<td>88</td>
</tr>
<tr>
<td>Anosmia score (0–10)</td>
<td>9.1</td>
<td>8.7</td>
<td>-0.4</td>
<td>95</td>
</tr>
<tr>
<td>Nasal discharge score (0–10)</td>
<td>7.5</td>
<td>8.1</td>
<td>0.6</td>
<td>108</td>
</tr>
<tr>
<td>Sneezing score (0–10)</td>
<td>4.3</td>
<td>4.8</td>
<td>0.5</td>
<td>110</td>
</tr>
<tr>
<td>Overall symptom severity (0–10)</td>
<td>41.6</td>
<td>40.7</td>
<td>-0.9</td>
<td>98</td>
</tr>
<tr>
<td>Percent with polyposis</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Percent with asthma</td>
<td>45</td>
<td>60</td>
<td>15</td>
<td>132</td>
</tr>
<tr>
<td>Total procedures planned</td>
<td>11.2</td>
<td>10.7</td>
<td>-0.5</td>
<td>95</td>
</tr>
<tr>
<td>Surgical variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent receiving general anesthesia</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Percent undergoing primary surgery</td>
<td>73</td>
<td>53</td>
<td>-19</td>
<td>73</td>
</tr>
<tr>
<td>Total procedures performed</td>
<td>11.6</td>
<td>10.4</td>
<td>-1.2</td>
<td>90</td>
</tr>
<tr>
<td>Duration of surgery (min)</td>
<td>126.9</td>
<td>118.1</td>
<td>-8.8</td>
<td>93</td>
</tr>
<tr>
<td>Difficulty of surgery</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent less than average difficulty</td>
<td>36</td>
<td>27</td>
<td>-10</td>
<td>73</td>
</tr>
<tr>
<td>Percent average difficulty</td>
<td>45</td>
<td>33</td>
<td>-12</td>
<td>73</td>
</tr>
<tr>
<td>Percent more than average difficulty</td>
<td>18</td>
<td>40</td>
<td>22</td>
<td>220</td>
</tr>
<tr>
<td>Estimated blood loss (mL)</td>
<td>225.9</td>
<td>222.7</td>
<td>-3.2</td>
<td>99</td>
</tr>
<tr>
<td>Mucosal health</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent healthy</td>
<td>64</td>
<td>53</td>
<td>-10</td>
<td>84</td>
</tr>
<tr>
<td>Percent slightly inflamed</td>
<td>27</td>
<td>13</td>
<td>-14</td>
<td>49</td>
</tr>
<tr>
<td>Percent severely inflamed</td>
<td>9</td>
<td>33</td>
<td>24</td>
<td>367</td>
</tr>
<tr>
<td>Endoscopic score, right</td>
<td>4.6</td>
<td>5.1</td>
<td>0.5</td>
<td>111</td>
</tr>
<tr>
<td>Endoscopic score, left</td>
<td>4.5</td>
<td>4.9</td>
<td>0.4</td>
<td>109</td>
</tr>
<tr>
<td>Endoscopic score, total†</td>
<td>9.0</td>
<td>9.9</td>
<td>0.9</td>
<td>110</td>
</tr>
</tbody>
</table>

*placebo group value – treatment group value)/(placebo group value); 40% difference between groups was deemed to be clinically significant.
†Summation scores.

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treatment effect on subjective symptoms noted between treatment groups for prednisone compared with placebo.

**Steroid effect on objective outcomes.** As assessed by the LKES, there was a statistically significant difference noted in the prednisone group between baseline and the 2-week, 4-week, and 6-month time points (Table II). No such differences were noted with the placebo group. In addition, a statistically significant difference in the POSE score was noted between treatment groups at 2 weeks (prednisone better, \( P < .001 \)). Although this trend continued at later time points, it was not statistically significant with the Bonferroni adjustment.

**Repeated Measures Analysis: Treatment Effect**

As shown in Table III, there are consistent, statistically significant differences noted between baseline and postoperative scores for most symptoms in both the treatment and placebo groups. However, there is no treatment effect detected regarding symptoms. In contrast, the difference between baseline and postoperative scores is not only statistically significant for both groups, but it also shows a statistically significant treatment effect, with lower endoscopy scores (i.e., healthier cavities) in the prednisone group.

**Comparison of POSE Score with LKES**

As might have been expected for two scoring systems designed to collect similar data albeit in slightly different formats, the average, descriptive data for both the POSE and LKES were similar (discharge, scarring, crusting). The one area of difference is with respect to the spectrum of edema, polypoid change, and polyposis. Because the LKES does not subdivide this spectrum to the degree that the POSE instrument does, the summary data for these parameters were quite different, again as would have been expected a priori. When examined for trends (Fig. 2), the POSE-32, POSE-40A, and the LKES show consistent sensitivity to change, with parallel improvement to 1 month, a slight increase in scores (worse symptoms or endoscopy) at 3 months, and, finally, improvement to 6 months. In addition, it is worth noting that all but two patients had either sphenoidotomy, frontal recess surgery, or both performed. Thus, postoperative data were collected on 24 of 26 patients regarding the state of these sinuses.

**Correlation Among POSE Score, LKES, and Subjective Measures**

Moderate degrees of correlation were noted overall between the POSE-32 and the POSE-40A and the SSQ, with Pearson \( R = 0.49 \) and 0.51, respectively. In all cases, correlations were also noted between the SSQ and the LKES, and at all data points the correlations were stronger.

---

**TABLE II.**

**Repeated Measures Analysis: Treatment Effect**

<table>
<thead>
<tr>
<th>Change From Baseline</th>
<th>Treatment Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>( P )</td>
</tr>
<tr>
<td>F</td>
<td>( P )</td>
</tr>
<tr>
<td>Total endoscopy score</td>
<td>18.504 &lt;.001</td>
</tr>
<tr>
<td>Nasal blockage</td>
<td>31.690 &lt;.001</td>
</tr>
<tr>
<td>Headache</td>
<td>1.008 .45</td>
</tr>
<tr>
<td>Facial pain</td>
<td>1.396 .30</td>
</tr>
<tr>
<td>Anosmia</td>
<td>6.506 .008</td>
</tr>
<tr>
<td>Nasal drip/discharge</td>
<td>9.613 .002</td>
</tr>
<tr>
<td>Sneezing</td>
<td>3.496 .049</td>
</tr>
<tr>
<td>Overall symptom severity</td>
<td>14.847 &lt;.001</td>
</tr>
<tr>
<td>SSQ total score</td>
<td>29.580 &lt;.001</td>
</tr>
</tbody>
</table>

\( F = F \) ratio (variance ratio or estimate of variance between groups); SSQ = Sinus Symptom Questionnaire.

---

**TABLE III.**

**Comparison of Symptoms Over Time in Prednisone vs. Placebo Group.**

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>2 Weeks</th>
<th>4 Weeks</th>
<th>3 Months</th>
<th>6 Months</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prednisone</td>
<td>Placebo</td>
<td>Prednisone</td>
<td>Placebo</td>
<td>Prednisone</td>
</tr>
<tr>
<td>No.</td>
<td>11</td>
<td>15</td>
<td>11</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>Total endoscopy score (LKES)</td>
<td>9.0</td>
<td>9.9</td>
<td>4.6*</td>
<td>8.0</td>
<td>4.6*</td>
</tr>
<tr>
<td>Perioperative Sinus Endoscopy Score</td>
<td>n/a</td>
<td>n/a</td>
<td>7.8†</td>
<td>15.4</td>
<td>8.4</td>
</tr>
<tr>
<td>No.</td>
<td>10</td>
<td>12</td>
<td>10</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>Nasal blockage</td>
<td>8.3</td>
<td>8.2</td>
<td>1.5*</td>
<td>1.5*</td>
<td>1.4*</td>
</tr>
<tr>
<td>Headache</td>
<td>2.7</td>
<td>2.2</td>
<td>1.7</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Facial pain</td>
<td>2.0</td>
<td>1.8</td>
<td>0.5</td>
<td>0.3</td>
<td>0.6</td>
</tr>
<tr>
<td>Anosmia</td>
<td>9.1</td>
<td>8.7</td>
<td>2.3*</td>
<td>6.2</td>
<td>1.9</td>
</tr>
<tr>
<td>Nasal drip/discharge</td>
<td>7.5</td>
<td>8.1</td>
<td>2.6</td>
<td>3.3*</td>
<td>1.8</td>
</tr>
<tr>
<td>Sneezing</td>
<td>4.3</td>
<td>4.8</td>
<td>2.0</td>
<td>2.5</td>
<td>1.9</td>
</tr>
<tr>
<td>Overall symptom severity</td>
<td>6.7</td>
<td>7.1</td>
<td>1.7</td>
<td>1.8*</td>
<td>1.3</td>
</tr>
<tr>
<td>Symptom severity questionnaire score</td>
<td>41.6</td>
<td>40.7</td>
<td>12.4*</td>
<td>16.3*</td>
<td>9.7*</td>
</tr>
</tbody>
</table>

* \( P < .001 \) versus baseline; † \( P < .001 \) versus placebo.
for the POSE score than for the LKES (Fig. 3), although these were not statistically different. It is worth noting as well that correlations between all three endoscopic scales and the CSS were weak and statistically nonsignificant.

**Correlation Between POSE Score and LKES**

As shown in Table IVA, correlations between the POSE-32, POSE-40A, and the LKES were generally strong (range, 0.67–0.88). These correlations were also statistically significant at \( P < .001 \).

Table IVB presents the degree of correlation between changes, from one data point to the next, in the LKES and both the POSE-32 and POSE-40A. Again, all correlations are statistically significant (\( P < .001 \)) and strongly positive (\( R = 0.77–0.83 \)).

**Predictive Power of POSE Score**

Bivariate correlation analysis was performed to determine the predictive power of both objective and subjective scores at the 2-week time point as compared with the net symptomatic response (difference between SSQ at baseline and 6 mo). None of the correlations were significant (\( P \geq .29 \)), and all were weak (\( R = 0.08–0.27 \)).

**Comparison between Treatment Groups Using Endoscopic Scales**

As a final step, the difference between the steroid-treatment group and the placebo group was compared, from 2 weeks through 6 months, using the three scales, the LKES, POSE-32, and POSE-40A. Figure 4 depicts the data using the LKES and the POSE-32. What is apparent using the two POSE scales is that there is a steady worsening in function from 1 month on in the placebo group but not in the prednisone group. This distinction is not apparent or detected using the LKES.

**DISCUSSION**

The current study is a randomized, double-blind, placebo-controlled study examining the effect of perioperative systemic steroids on surgical outcomes in patients undergoing ESS for treatment of CRSwP. Both subjective and objective outcomes measures were used, including a newly developed POSE reporting scale. The primary objective of the study was to assess, in a detailed fashion, the effect of the steroids on these subjective and objective outcomes in the short and medium term. The secondary objective was to begin to validate the new sinus endoscopy
Impact of Systemic Steroids on Technical Aspects of Surgery

A frequent justification for the use of systemic steroids preoperatively in patients undergoing ESS for treatment of CRSwP is that it will facilitate the surgery. The rationale includes less bleeding, better visualization, and less trauma to the tissues. This study therefore sought to provide some evidence to support what is, at best, expert opinion only and not uniformly practiced.

The findings of this study demonstrate that there is a clinically significant difference detected in the technical difficulty of surgery, with patients not receiving preoperative systemic steroids being more likely to have a procedure rated by the surgeon to be of more than average difficulty. Furthermore, patients who did not receive preoperative systemic steroids were far more likely to have sinonasal mucosa rated as severely inflamed. These differences were rated as significantly different clinically, although, likely because of the nature of the 3-point scale used and the sample size, statistical significance was not noted. Finally, the operative data such as estimated blood loss and duration of surgery showed no difference at all between groups, possibly because these variables are subject to influence by multiple factors (equipment, nursing, trainee participation). When considered in terms of clinical relevance, the complication rate for ESS is already extremely low, and it would be well beyond the power of this study to demonstrate that the use of preoperative steroids would reduce their incidence. However, in the present study, there were instances in the placebo-treated group in which suboptimal visualization resulted in less complete surgery than was planned, a finding not noted in the prednisone group.

The subjective data regarding ease of surgery and mucosal health in the estimation of the operating surgeon was collected because it was believed to be clinically relevant as an outcome measure for the study question. These data are also less subject to external influences as compared with operative time and blood loss. However, the

scale by comparing it, in the context of this study, with the currently accepted standard.

### Impact of Systemic Steroids on Technical Aspects of Surgery

A frequent justification for the use of systemic steroids preoperatively in patients undergoing ESS for treat-
mucosal health and impact of bleeding and swelling on intraoperative visualization can be viewed as rather subjective in nature and thus prone to bias. The randomized, double-blind nature of the study should mitigate this potential bias of subjective measures. Finally, it is noteworthy that the two variables, ease of surgery and mucosal health, which can be linked in a causal relationship, both show a similar trend, whereas all of the other operative variables show no difference.

**Impact of Steroids on Subjective Outcomes (Symptoms)**

The impact of ESS on subjective outcomes for both groups was demonstrated in this study to be clinically significant and statistically significant to 4 weeks postoperatively. Thereafter, there was a significant trend noted that was not of statistical significance. The only treatment effect noted of prednisone was improved olfaction at 2 weeks as compared with baseline ($P < .01$) as well as a notable trend to improved olfactory symptoms at the 1-month time point, which was not noted in the placebo group. These limited subjective findings are not surprising in the context of recent and classic literature that suggest that subjective symptoms are unreliable in diagnosing CRS$^{19,20}$ and that postoperative endoscopic findings in patients with CRSwP frequently do not correlate with symptoms.$^{19,20}$

**Impact of Steroids on Objective Outcomes (Endoscopy)**

With use of the Lund-Kennedy endoscopic scoring system to compare patients at baseline and in the postoperative period, there were statistically significant improvements noted at most time points for the prednisone group but not for the placebo-treated groups. This finding was corroborated by the ability to detect a treatment effect (RM-ANOVA) of prednisone for the objective finding of nasal endoscopy. Thus, the patients receiving prednisone had clinically and statistically significantly healthier cavities overall, although it should be emphasized that only the specific time point of 2 weeks was statistically significant in an intergroup comparison. This finding for comparison between groups was also demonstrated using the POSE score.

When examined overall at all time points, there was a notable, although not statistically significant, trend to lower endoscopy scores for patients who had received prednisone. A larger sample size could be reasonably expected to permit this trend to achieve statistical significance, at least for the POSE score, in which the trend was stronger. However, the sample size calculation ($n = 24$) had been made preoperatively under the assumption that a clinically relevant difference between groups would be represented by a 40% difference. Thus, to be consistent with the a priori decision that the sample size was sufficient to detect a clinically significant difference, we should conclude that the impact on endoscopic postoperative outcomes is detectable only in the short term (2 wk) but not in the medium term (6 mo).

The relative merit of subjective, symptom-based outcomes measures for patients post-ESS versus subjective, endoscopy-based measures does not represent a new debate. Rather, it has been the source of significant scholarly activity and symposia.$^{20,21}$ Although the clinical outcomes assessed by symptom-based, disease-specific instruments such as the CSS and Rhinosinusitis Outcome Measure have been described as reliable at detecting reduction in both symptoms and medication use,$^{22}$ these results are not necessarily predictive of long-term results. In contrast, there is strong evidence that endoscopic examination of the sinonasal cavity in the postoperative period provides prognostic information concerning the potential for recidivism.$^{20}$ The critical time period for this prognostic information is at 18 months postoperatively because a healthy cavity at that time is associated with excellent long-term (7.8 yr) outcome, whereas evidence of persisting mucosal abnormalities at 18 months was significantly correlated with subsequent revision surgery.$^{22}$ In the present study, the detection of a treatment effect based on endoscopic findings but not for symptoms is consistent with the perspective of those arguing that endoscopic outcomes are an essential part of the postoperative course for patients undergoing ESS for CRSwP. It further suggests that endoscopy may be a more sensitive manner with which to follow patients after ESS and further supports the recommendations of the Rhinosinusitis Task Force that postoperative endoscopic reporting using the Lund-Kennedy scale be included in data collection for large clinical studies.$^{14}$

**Comparison of the POSE Score with LKES**

For the purposes of this study, a new endoscopic scoring system was developed with the aim of enhancing face validity, responsiveness to change, and to be more data rich. To begin validation of this scoring system, it was necessary to compare it with the existing gold standard, in this case, the LKES. The data presented suggest that the POSE is at least as sensitive to change as the LKES, and when compared graphically, the POSE appears to have been more sensitive to later worsening of score in the placebo group at 6 months as compared with the prednisone group.

The POSE score was found to correlate highly with the LKES both in terms of absolute score and change in score and can thus be concluded to, at worst, be comparable with the LKES. It is also noteworthy, as outlined previously, that neither endoscopic scoring system correlated well with symptoms scores but that the POSE did correlate more strongly.

What is apparent from the scoring system itself is that the POSE score gives more information and detail regarding secondary sinuses, the spectrum of inflammation in the ethmoid cavity, and the degree of scarring or outflow obstruction in the middle meatus. This immediately enhances face and content validity, key first steps in validating it as a new scoring system for sinonasal endoscopy in CRS. Coupled with the preliminary evidence that it may also be more sensitive to change over time, these data suggest that the POSE is worthy of further study and efforts at validation.

There are several steps planned to validate the POSE scoring system. To begin, additional outcomes studies with control groups and larger numbers than the present
experiment are essential. This will permit more sophisticated statistical analysis including regression analysis. A second key step in validating the POSE scoring instrument would be to assess interobserver variability as a measure of accuracy of the instrument as well as intraobserver variability as a measure of reliability. This step would also enable assessment of the ease of use of the instrument because, despite its intuitive nature for experienced sinus surgeons, it collects more data and might be thought by some to be more cumbersome than the LKES. It may also be of value to confirm the enhanced face and content validity by subjecting the POSE scoring system to a focus group of rhinologists/endoscopic sinus surgeons. Finally, it would be of great interest to examine this scoring scale in the context of a residency training program because using it can be seen to have formative value by focusing the trainees’ endoscopic assessments on the findings that are believed to be most important.

For future studies involving the POSE scoring system, a baseline score will be assigned based on operative findings. This was not done for the current study and did limit the ability to compare the two study groups somewhat. Although the scoring system was initially developed for collecting data in the postoperative phase of treatment, a thoughtful hindsight review of the instrument reveals that a score at the time of surgery could be (and probably should have been) assigned for all of the components, which would allow measurement of change not only between postoperative time points but also with baseline scores (Appendix II, online only).

Implications of the Study in the Context of Evidence-Based Practice

As noted by Rosenfeld,23 there is an increasing quantity and quality of clinical research in the otolaryngology literature at the expense of descriptive and review articles. However, this same study noted that more than 80% of these clinical studies were uncontrolled and retrospective and often failed to predetermine a necessary sample size. Recent years have seen more systematic approaches to clinical questions and a more critical appraisal of the literature, including the question of the effectiveness of ESS for CRS.3 These authors point out that most evidence regarding ESS is level 4 (retrospective case series) and is limited by the absence of a comparison group. They further go on to recommend that future efforts be prospective and incorporate appropriate comparison groups. Although not addressing the same specific question, the present study is intended to add further grist to the evidence mill regarding ESS and the management of CRS.

As outlined by Sackett and Rosenberg, and Sackett et al.,24,25 the components of evidence-based medicine are clinical experience and expertise, the best current evidence from the scientific literature, and patient/societal values. These components are used in the decision-making process for a given patient, for example, in the perioperative management of a patient undergoing ESS. Based on the current study, there is sufficient evidence to support the practice of administering perioperative systemic steroids to patients undergoing ESS for treatment of CRSwP. What the individual clinician will need to consider is the value for his/her patient in the context of his/her clinical expertise and postoperative care regimen. What is apparent from the evidence presented in this study is that there is a demonstrable improvement in endoscopic appearance of the sinus cavities in the short term (2–4 wk) but that the effect wanes. Thus, if the clinician makes it a practice priority to provide intense postoperative care and makes decisions regarding ongoing medical therapy based on the appearance of the cavities and not on the patient’s symptoms, then there is value in using postoperative steroids in that context. The postoperative steroids can be viewed in this context as helping to get healing and medical postoperative management off to a good start but cannot be viewed as sufficient in the long term. By contrast, if the clinician does not routinely base clinical management on the endoscopic appearance of the cavities but rather intervenes based on redevelopment of symptoms and is not in the practice of using aggressive medical therapy as needed in the months after surgery, the value of postoperative systemic steroids would be questionable, and the surgeon would be advised to reconsider the value of postoperative steroids. With use of similar logic, the value of preoperative steroids would appear to be of value to virtually all patients undergoing ESS for CRSwP because it has been demonstrated to improve sinonasal mucosal health/integrity as assessed clinically and also to render the surgery less difficult in a larger percentage of patients receiving prednisone versus those receiving placebo.

A concept related to evidence-based practice is one of practice guidelines or clinical pathways, constructs that help clinicians make decisions in specific clinical circumstances, for example, patients undergoing ESS. When one practice guideline was studied several years ago, it was found that patients following the pathway were less likely to undergo unplanned admission and that their hospital costs were lower while maintaining comparable clinical outcomes. The current study may be of interest to those developing future clinical pathways for patients undergoing ESS.

CONCLUSIONS

Based on the data collected and analyzed in this study, several conclusions can be drawn as related to the study objectives. First, pretreatment with systemic steroids appears to confer the advantages of facilitating surgery and improving the health of the sinonasal mucosa, and, therefore, in the context of evidence-based practice, there is sufficient evidence to support the preoperative administration of systemic steroids to all patients undergoing ESS for CRSwP. Second, treatment postoperatively with systemic steroids results in endoscopically healthier sinus cavities in the short term, an outcome of relevance if the goal of sinus surgery for these patients is to achieve an endoscopically healthy sinonasal cavity in the long term. Thus, in the practice of surgeons who provide intensive postoperative care for patients post-ESS, including debridement and medical therapy, as based on the endoscopic findings, there is evidence to support administering systemic steroids in the postoperative period in an effort to optimize the initial endoscopic appearance of the cavities.
With respect to endoscopic evaluation of patients post-ESS, the POSE scoring tool correlated highly with the existing standard in the form of the LKES and may confer advantages in terms of face/content validity and sensitivity to change by including additional information regarding secondary sinuses and the ethmoid cavity. The POSE instrument will require further validation studies but shows promise as an objective outcome measure for future studies involving the surgical management of CRS.

Acknowledgments
The author acknowledges the support and guidance of his sponsors for candidacy in the Triological Society, Drs. Howard Lampe and Lorne Parnes. In addition, he has had the good fortune to have many other mentors and role models in his career and would like to thank Drs. Martin Black, Saul Frenkkel, Martin Desrosiers, David Kennedy, Donald Lanza, and William Bolger and for their encouragement and generosity in sharing their expertise and knowledge. He would also thank his parents for their personal and professional lives. Finally, and most importantly, he would like to acknowledge the support of his wife Stacey and daughters Jordyn, Abigail, and Zoe, whose indulgence of the time required for undertaking this thesis was essential to its successful completion.

BIBLIOGRAPHY


APPENDIX

Appendix I: Supplementary Literature Review

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Chronic Rhinosinusitis (CRS): The Magnitude of the Problem

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  - Clinical Presentation of Disease
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  - Corticosteroids in the Medical Management of CRS and Nasal Polyposis
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  - Published Outcome Measures for CRS and Nasal Polyposis
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Chronic Rhinosinusitis: The Magnitude of the Problem

CRS is an inflammatory disease of the sinonasal tract that is of multifactorial etiology and complex classification. It occurs spontaneously in isolation but also is a relatively common comanifestation of diseases such as
chronic asthma, allergic rhinitis, cystic fibrosis, and inflammatory bowel disease. Traditionally discounted as a relatively benign condition, it has warranted increasing attention in recent years as awareness has grown of the significant societal impact it has. This impact relates not only to its relatively high prevalence, for example, affecting up to 16% of adults in the United States, 17% in the United Kingdom, and 13.5% in Canada, but also to the significant effect it has on patient quality of life and the economic burden it places on society, both in terms of direct health care costs and indirect costs secondary to loss of productivity. In one study, 322 adult patients were studied prospectively. The average patient had received 2.7 courses of antibiotics and used nasal steroids and prescription antihistamines for 18.3 and 16.3 weeks over the preceding year, respectively. Mean direct health care costs were $921 U.S. per patient-year. CRS caused an average of 4.8 days of missed work per 12-month period. The overall yearly economic cost of CRS was estimated at $1,539 per patient. In another U.S. study, annual per-patient medication costs alone were estimated at $1,200.

These costs amount to billions of dollars in direct costs each year in addition to the estimated 250,000 endoscopic ethmoidectomies performed each year in the United States. Thus, CRS is a common disease that exacts a significant toll on society in terms of direct costs and lost productivity, for which hundreds of thousands of patients undergo surgical treatment each year.

Etiology of CRS

The precipitating cause of CRS remains elusive in many cases. As stated above, it frequently is seen in association with chronic asthma, with rhinitis occurring in approximately 75% of allergic asthmatics and asthma developing in 20% of those with seasonal allergic rhinitis. Moreover, comorbidity with asthma is associated with worse endoscopic evidence of rhinosinusitis and a less satisfactory response to endoscopic surgical management. A common thread through both conditions is the presence of eosinophilia, which, similar to asthma, is associated both with more severe endoscopic evidence of sinusitis and a poorer response to treatment. Eosinophilia also is associated with nasal polyposis, both with and without CRS. CRSwP, in turn, is associated with greater symptoms and overall worse disease than CRS without polyposis. The above-described findings have led many authors to conclude that these seemingly disparate respiratory tract inflammatory conditions are, in many cases, actually manifestations of one common systemic disease.

One currently popular theory regarding the association between CRSwP, asthma, and eosinophilia is that a chronic inflammatory response occurs in response to bacterial superantigens. Also, more than one research group recently has identified the presence of bacterial biofilms within the sinuses, which may serve as a trigger for the chronic inflammatory response.

In cases of CRS without polyposis, chronic bacterial infection has been implicated as an etiologic factor. In contrast with acute bacterial rhinosinusitis, a higher incidence of Staphylococci has been described in CRS, including methicillin-resistant Staphylococcus pneumoniae and Moraxella catarrhalis. Other common pathogens, particularly in patients who have undergone previous surgery, include Haemophilus influenzae, Streptococcus pneumoniae, and Pseudomonas aeruginosa and a-hemolytic streptococci. Moreover, one group has identified a higher prevalence of Helicobacter pylori than expected among individuals with nasal polyposis.

In contrast, other studies have failed to support a bacterial role in CRS causation. In one of these studies, positive cultures at the time of surgery were no different between patients with and without polyposis, and in the absence of gross purulence visible endoscopically, some authors question the utility of antibiotics at all. Antibiotics do appear to have some beneficial effect in the management of noninfectious CRS, but this generally pertains to the macrolide agents, which have been suggested to possess significant anti-inflammatory attributes. This anti-inflammatory role for macrolides has held variable degrees of favor in recent years.

Fungal infections commonly are associated with local and systemic eosinophilia. These findings have led investigators in recent years to suggest a role for fungi in the pathogenesis of CRS and nasal polyposis. These authors have found fungus to be ubiquitous on sinonasal culture using highly sensitive techniques and propose the theory that the afflicted patient populations react in an exaggerated fashion to these fungal antigens as compared with nonafflicted people. Again, however, the evidence is inconclusive and debate continues. Other risk factors for the development of CRS are air pollution and chronic cigarette use.

Pathophysiology of CRS With Polyposis

As stated above, the mechanisms by which CRS and nasal polyposis develop are not entirely understood. However, considerable evidence suggests that both conditions result from chronic inflammation with resultant tissue hyperplasia. That eosinophils play a role, in at least a subset of CRS patients and patients with nasal polyposis, is quite evident. In fact, eosinophilia often is apparent, both systemically and locally, within inflamed nasal mucosa and within polyps themselves. However, eosinophilia is not always present. In one study in which biopsies were obtained from the inferior turbinates of 14 patients with nonallergic CRS versus 10 healthy controls, significant increases (P < .05) were detected in numbers of CD3, CD4, and CD8 T cells and B cells in the nasal mucosa of patients with CRS; however, the numbers of CD68 cells and eosinophils were not elevated.

In another study, 29 adults with refractory chronic sinusitis underwent functional ESS (FESS) after standard preoperative computed tomography (CT). Six patients with normal sinus mucosa served as control subjects. Patients were subdivided into two groups according to their dominant pathologic features: 16 had polypoid mucosa and peripheral eosinophilia, and 13 had glandular hyper-
The numbers of eosinophils, and of T and B lymphocytes in the lamina propria, were significantly higher in patients with polyoid mucosa and eosinophilia versus those with glandular hyperplasia and versus normal control subjects, whereas the differences between patients with glandular hyperplasia and control subjects were insignificant. Although the overall inflammatory reaction was relatively modest, nasal polyposis was more prevalent in patients with polyoid mucosa and eosinophilia; likewise, CT revealed significantly more extensive disease in these patients versus those with glandular hyperplasia. It can be concluded from this evidence that most patients with polyposis appear to have a more intense, and potentially systemic, inflammatory response associated with inflammatory cells, including eosinophils.

Results from these two studies suggest that there may be more than one overall mechanism by which CRS and nasal polyposis develop. At least one such mechanism is associated with significant eosinophilia, immunoglobulin E production, and atopy. Another appears to be nonallergic, associated more with T-lymphocyte and neutrophil predominance. These conclusions are further supported by the Th2 versus Th1 cytokine profiles seen in CRS patients with and without atopy, respectively. Various subsets of T lymphocytes appear to be more important than others in the pathologic process of CRS, with or without nasal polyposis. In one study, biopsies were taken from the uncinate process, the maxillary, ethmoid sinuses, and the middle and inferior turbinates of 32 patients (20 male, 12 female) with chronic sinusitis who had undergone ESS and compared with biopsies taken from the inferior turbinate of 8 control, nonsinusitis patients (5 male, 3 female) who had undergone septoplasty. With use of an immunohistochemical staining technique with monoclonal antibodies against CD3, CD4, and CD8 surface antigens of T lymphocytes, all tissue levels were examined. Statistical analysis revealed that the number of CD3 in the epithelial layer of the inferior turbinate (P = .030) and the number of CD4 in the deep layer of the middle turbinate (P = .048) were significantly higher than the corresponding values among controls. Among those with CRS, differences between the CD4+ and CD8+ cell counts were identified in the epithelial (P = .018) and subepithelial (P = .012) layers of the uncinate process; in the epithelial (P = .050) and subepithelial (P = .012) layers of the ethmoid sinus; and in the subepithelial (P = .018) and deep paraganglular (P = .012) layers of the middle turbinate. The number of CD4+ cells consistently was higher than the number of CD8+ cells, and CD4+ T-helper cells appeared to be especially predominant in the initiation and regulation of inflammation. In another study involving 12 patients with CRS and polyposis, both local and systemic influx of CD4+ lymphocytes was evident in response to Staphylococcal exotoxins, including inflammation within the polyps themselves, prompting these and other investigators to conjecture that CD4+ cells present Staphylococcal or other infectious superantigens as an initiating and propagating step in the development of CRS and associated polyposis.

Eosinophilia also has been observed as a response to Staphylococcal superantigens, and both eosinophils and T lymphocytes appear in the setting of a diverse array of cytokines so as to accentuate and perpetuate the inflammatory response. Recent research suggests that a chemokine called RANTES (regulated on activation, normal T-cell-expressed, and secreted), a member of the CC chemokine family with chemotactic activity directed primarily toward eosinophils and T lymphocytes, may be very important in the recruitment of eosinophils and T lymphocytes into the nose in patients with CRS and nasal polyposis. Several additional chemokines such as eotaxin and monocyte chemotactic proteins have also been implicated as contributing factors in the development of eosinophilia in CRSwP.

Hyperplasia of tissue, secondary to the local inflammatory response, results in a variety of the symptoms and complications of CRS, including polyposis. Mucin gene up-regulation probably is responsible for the mucous hypersecretion that can be so clinically prominent and problematic.

It can thus be seen from the previous summary that CRS is a complex disease with multiple proposed etiologies. Significant progress is being made with respect to our understanding of the molecular and immunopathologic mechanisms that underlie this disease, the common denominator of which is an intense, perpetuated inflammatory process, which drives the formation of polyps and hyperplastic mucosa. It is this inflammatory process that is also the target of virtually all forms of therapy currently available to clinicians treating patient with CRS.

Clinical Presentation of Disease

CRS, with or without nasal polyposis, is associated with a myriad of clinical symptoms that commonly include facial pain or pressure; facial congestion or fullness; nasal congestion or obstruction; rhinorrhea; hyposmia or anosmia; low-grade fever; chronic cough; headache; halitosis; fatigue; dental pain; and ear pressure or pain. Of these various symptoms, the most common major symptoms are nasal obstruction, observed in 94% of patients; facial congestions (85%); and nasal discharge (82%); the most common minor symptom is headache, observed in 83%.

The Rhinosinusitis Consensus Research Definitions and Clinical Trial Guidelines list four different categories of sinusitis: recurrent acute sinusitis; CRSwP; CRS without polyposis; and classic allergic fungal sinusitis. Consequently, different sets of classification criteria have been created, primarily distinguishing acute bacterial rhinosinusitis from other types of rhinosinusitis. Both include lists of major and minor symptoms, and both have requirements for at least two major criteria or one major and two minor criteria for a diagnosis of probable rhinosinusitis. Both criteria sets include purulent anterior nasal drainage and purulent posterior drainage as major symptoms. Most of the other symptoms listed above are given largely as minor criteria for acute rhinosinusitis or some as major and others as minor criteria for rhinosinusitis, acute or chronic. The current paper and research study focus on CRS rather than acute or allergic fungal sinusitis and, in particular, on CRSwP.
Nonsurgical Management of CRS and Nasal Polyposis

ESS or FESS generally is reserved for patients with CRS, with or without nasal polyposis, who are refractory to maximal medical management. However, this subgroup constitutes the minority of patients. Most patients respond to one or a combination of treatments that may include antihistamines, nasal decongestants, antibiotics, and corticosteroids. Of these, antibiotics and corticosteroids have warranted the greatest research interest.

Although the microbiology of purulent CRS is well documented, the treatment of this condition is not easily based on solid evidence. There is fairly solid evidence that endoscopically guided cultures can be helpful in identifying offending organisms in CRS, and using this information to direct antimicrobial therapy is a commonly accepted practice. The most recent guidelines addressing the issue of therapy selection and duration still recommend 4 to 6 weeks of uninterrupted therapy for CRS. These same authors also report the frequent use of anaerobic coverage as part of this regimen.

When chosen for use, a variety of different antibiotic regimens have been touted as effective, including amoxicillin/clavulanic acid, the macrolides (such as clarithromycin), ciprofloxacin and newer fluoroquinolones, trimethoprim/sulfamethoxazole. Although usually taken orally, some treatment regimens warrant intravenous or intranasal delivery of these drugs. However, in general, clinical trials involving antibiotics have been small, or noncontrolled, or of short duration, and relapse rates have been as high as 89%. Moreover, the use of antibiotics is not without the risk of complications. Intrapulmonary antibiotics are prone to a variety of catheter-related complications, albeit in a small minority, and all antibiotics carry the risk of drug reactions and the development of resistance. In patients who have failed more traditional medical regimens, potentially including CRS associated with chronic purulence, selective irrigation of the sinuses with a solution containing antibiotics and corticosteroids has shown potential.

Perhaps the most interesting and novel evidence supporting the benefit of antibiotics involved a study of mucociliary clearance in patients treated with antibiotics for CRS. The respiratory tract is lined by an epithelium comprising mucus producing cells and ciliated cells that serves as the first line of defense in the upper and lower respiratory tracts. Failure of mucociliary clearance is associated with chronic or recurrent respiratory tract infection. In this study, 10 patients with CRS underwent nasal brushings for the assessment of ciliary beat frequency, who then received 3 months of continuous oral antibiotic therapy, after which repeat nasal brushings demonstrated increased ciliary beat frequencies in all patients (P < .01; paired t test). The authors concluded that depression of mucociliary clearance is a result of chronic sinonasal infection and that prolonged antibiotic use can help to restore mucociliary system function.

Although antibiotics are generally thought to be of benefit through their antimicrobial properties, which reduce bacterial infection and its associated host inflammatory response, considerable work has examined the anti-inflammatory/immunomodulatory effects of the macrolides, an effect that may be more important in CRS than their antimicrobial effect. Clarithromycin, in particular, has been demonstrated to have a variety of immunosuppressant effects, including in vitro reduction in the cellular production of transforming growth factor-beta and nuclear factor-kappa B and of interleukin-5, interleukin-8, and granulocyte-macrophage colony-stimulating factor. In fact, some authors are currently recommending macrolide therapy as a standard part of maximal medical therapy prior to considering a patient as a candidate for ESS.

Further evidence supporting the value of immunomodulating therapy in CRS comes from a recent pilot study involving the use of interferon (IFN)-gamma. In this study, 10 patients with treatment-resistant CRS (4 males and 6 females) who had been treated with exogenous IFN-gamma (50 μg/m2) were evaluated by retrospective assessment of clinical outcomes compared with clinical and laboratory findings before IFN-gamma treatment. Prior to treatment, all 10 patients had been suspected of having dysregulated IFN-gamma production. CRS in these patients was reported to be better controlled in all nine patients who received exogenous IFN-gamma for longer than 3 months. The authors concluded that exogenous IFN-gamma may be a therapeutic option in a subset of patients with treatment-resistant CRS and evidence of dysregulated IFN-gamma production. However, the greatest evidence both for the role of inflammation in the development and perpetuation of CRS and nasal polyposis and for the benefits of immunomodulating therapy stems from the apparent effectiveness of corticosteroids in the treatment of both conditions occurring singly or in combination.

Corticosteroids in Medical Management of CRS and Nasal Polyposis

The evidence that topical corticosteroids have a beneficial effect in CRS and nasal polyposis is quite compelling. As early as 1994, investigators histologically examined 11 patients with CRS and nasal polyposis who had been treated for 1 month with the topical nasal steroid budesonide, 200 to 400 μg/day, and compared them with 10 untreated patients. Overall, the authors found that most eosinophils in the examined nasal tissues were in the stromal layers and that the proportion of activated eosinophils (EG2+ vs. total eosinophil count) was significantly lower in polyps from steroid-treated patients. Also, in the polyps from treated patients, the superficial stromal layer and deep stromal layer both contained significantly fewer CD3, CD4, and CD8 T lymphocytes.

Subsequently, the benefit of various preparations of topical corticosteroids, such as betamethasone sodium phosphate nosedrops and beclomethasone dipropionate, fluticasone propionate, and budesonide nasal sprays, for CRS and nasal polyposis has been demonstrated in several randomized, placebo-controlled trials. The mechanism by which they work appears to be multifactorial, the effect being initiated by their binding to a specific cytoplasmic glucocorticoid receptor. At a cellular level, this results in a reduction in the number of antigen-presenting cells, in the number and degree of activation of T cells, in the number
of mast cells, and in the number and degree of activation of eosinophils. Topical corticosteroids are of use in the primary treatment of nasal polyps when they are of a small or medium size, but surgery is generally required for larger polyps because of the resultant nasal obstruction and limited access for topical preparations.

Corticosteroids also have been suggested to reduce the need for ESS. A recent study of 54 patients (28 males) scheduled for ESS because of severe nasal polyposis, CRS, or both were included in a 12-week, double-blind, placebo-controlled study. Half of the subjects were randomized to receive fluticasone propionate nasal drops (FPND) in a concentrated form. Use of intranasal steroid spray was stopped at least 4 weeks before randomization. Signs and symptoms were recorded before, during, and at the end of the treatment period. At the end of the study, a CT scan was performed, and the need for operation was reassessed by means of a standardized scoring method. ESS no longer was required in 13 of 27 steroid-treated patients versus only 6 of 27 in the placebo group \( (P < .05) \). Six patients from the placebo group dropped out versus one from the FPND group. Symptoms of nasal obstruction, rhinorrhea, postnasal drip, and loss of smell were reduced in the FPND group \( (P < .05) \). In addition, peak nasal inspiratory flow increased \( (P < .01) \) and polyv volume decreased \( (P < .05) \) in the steroid-treated group. This study provides evidence of effectiveness for topical steroids delivered in an alternate form but did not provide effective management in all cases.

Despite ample evidence that topical corticosteroids have efficacy in the preoperative medical management of rhinosinusitis, only recently have investigators started to look at the potential benefit of intranasal steroids postoperatively. The results have been mixed. One randomized, double-blind clinical trial examined the use of fluticasone propionate aqueous nasal spray (FPANS) to reduce the recurrence rate of nasal polyps and CRS during the first year after ESS. The trial randomized 162 patients, ages 18 years and older and requiring ESS for CRS or nasal polyps, either to receive FPANS 400 \( \mu \)g twice a day, FPANS 800 \( \mu \)g twice a day, or placebo twice a day for the duration of 1 year. Patients were withdrawn from treatment (but still included in statistical analysis) if they experienced recurrent or persistent disease, defined as progressive reformation of nasal polyps, recurrent signs and symptoms of chronic sinusitis combined with abnormalities on CT scan, or persistent complaints for at least 2 months after ESS. The investigators noted a significant reduction of symptoms after ESS. After 1 year, 46 patients had been withdrawn from the trial because of recurrent disease and 32 patients because of persistent symptoms. No differences in the number of patients withdrawn because of recurrent or persistent disease were found between the patients treated with FPANS and patients treated with placebo. There also was no discernable positive effect of FPANS compared with placebo in various patient subgroups (i.e., patients with polyps or patients without prior sinus surgery). The investigators concluded that there was no significant beneficial effect of topical steroids in patients who have undergone ESS.

Conversely, in another double-blind, placebo-controlled study of 26 patients with allergy to house dust mites who previously had had ESS but had persistent symptoms of disabling rhinorrhea or pressure-pain that was resistant to oral antibiotics and intranasal corticosteroids, 256 \( \mu \)g of budesonide administered daily through a maxillary antrum sinusotomy tube into one of the maxillary sinuses for 3 weeks was found to be superior to placebo. Eleven of the 13 patients who received budesonide responded compared with just 5 of 13 in the placebo group \( (P < .05) \); CD-3 and eosinophil counts also decreased locally \( (P = .002) \), and there was a decrease in the density of cells expressing interleukin-4 \( (P = .0001) \) and interleukin-5 messenger RNA \( (P = .006) \) after treatment. This slightly more invasive way of using topical corticosteroids suggests promise for the use of these medications in postoperative or medically refractory cases.

One question that remains to be answered, and which is the focus of this current paper, is the role of systemic corticosteroids perioperatively in patients undergoing ESS. As discussed in the following section, ESS is believed to be a highly successful procedure, but it is associated with complications and a relatively high rate of recidivism, both of which might be alleviated, at least to some degree, by the concurrent application of the potent anti-inflammatory properties corticosteroids induce. Also, in the following section, the value and merits of systemic steroids in the management of CRSwP will be discussed.

**Endoscopic Sinus Surgery**

ESS, sometimes called FESS, was first described in the North American scientific literature by Kennedy in 1985. It was touted as an effective way of reestablishing ventilation and mucociliary clearance of the sinuses, primarily by means of endoscopic removal of hypertrophic tissue and bone from key areas of the anterior ethmoid and middle meatus. In addition, sphenoethmoidectomy was possible while preserving the middle turbinate. The technique afforded the advantage of excellent visualization, with relatively minimal trauma, bleeding, and overall morbidity, so much so that, in 1994, Maran wrote, “Endoscopic nasal surgery has become the single major advance in the specialty of otolaryngology since the introduction of the operating microscope and middle ear surgery.”

Since that time, there have been numerous clinical studies demonstrating both the short-term and long-term benefits of ESS. These studies have documented improvement in a variety of parameters, from specific symptoms such as olfaction, to general health and quality of life. ESS even appears to benefit the asthma that commonly accompanies CRS. However, almost all of these studies have been uncontrolled. In a recent evaluation of the scientific validity of all published studies on ESS, 35 eligible studies were identified, both via a MEDLINE search for primary studies published from 1987 through 2001 and a review of several review papers. Criteria for this study were that the papers had to be written in the English language, had to have reported results on an adequate number of patients, and must have used the MeSH (medical subject headings) terms *sinusitis* (subheadings...
surgery or therapy) and endoscopy. Of these, only four studies were found to be controlled, so that the absence of a control group was considered to be the most important reason that published studies are unable to scientifically assess the efficacy of ESS relative to medical therapy and other sinus procedures.\textsuperscript{197}

Of the few controlled studies, the first, published in 1994, was a retrospective review of ESS versus the much more radical Caldwell-Luc operation (CLO).\textsuperscript{198} On the basis of the objective outcome measures of CT scans and endoscopic inspection, these authors, not surprisingly, demonstrated that ESS was more effective at producing healthy sinus cavities than the CLO.

More recent studies have compared ESS in combination with various preparations of corticosteroids versus corticosteroids alone. One was a comparison of ESS versus medical management involving oral corticosteroids, specifically treating patients with CRS, with and without nasal polyposis.\textsuperscript{199} Fifty-three patients were randomly allocated to receive oral prednisone for 2 weeks and 56 to undergo ESS. All patients were administered intranasal budesonide for 12 months. Patients were evaluated for nasal symptoms, polyp size, and general quality of life as measured on the Short Form 36 Health Survey (SF-36). At 6 and 12 months, a significant improvement in all SF-36 domains, except for physical functioning, was observed after both medical and surgical treatment, achieving levels observed in the general population. Nasal symptoms and polyp size also improved after both medical and surgical treatment at 6 and 12 months. However, there was no difference between the two treatment arms. This study provides evidence of the effectiveness of systemic steroids in the treatment of CRSwP and reinforces the widely held management principle that patients are only considered candidates for ESS when they have failed maximal medical therapy, generally including systemic steroids.

In another study, 90 patients with CRS with or without polyposis were randomized to receive either standard medical therapy primarily involving topical steroids and other supportive treatments or ESS.\textsuperscript{201} All patients underwent pre- and posttreatment assessments, which included measurement of symptom visual analogue scores, the Sinonasal Outcome Test-20 (SNOT-20), the SF-36, nitric oxide, acoustic rhinometry, saccharine clearance time, and nasal endoscopy. Each patient had three assessments: before starting the treatment, after 6 months, and after 1 year. Both the medical and surgical treatment of CRS significantly improved almost all the subjective and objective parameters of CRS (\(P < .01\)), with no significant difference being found between the medical and surgical groups, except for the total nasal volume, for which surgical treatment demonstrated greater improvement.

Recently, a controlled, prospective study was performed comparing the effect of medical treatment versus combined surgical and medical treatment on olfaction, polyp score, and symptoms in nasal polyposis.\textsuperscript{200} Thirty-two adults with bilateral nasal polyposis and symmetrical nasal airways were randomized to receive unilateral ESS after pretreatment with oral prednisolone for 10 days and local nasal budesonide bilaterally for 1 month. Postoperatively, patients were given local nasal steroids (budes-
ESS, with relatively few complications, but that only a small proportion of the evidence is comparative. Health economics data were found to be lacking and, therefore, inadequate for decision-making.

Similar findings were reported more recently by a steering committee of the American Rhinologic Society. These authors reviewed the literature for data regarding the efficacy of ESS in improving quality of life in patients who had failed medical therapy and who underwent surgery. These authors found 45 papers that met inclusion criteria. Virtually all of the papers were deemed to represent level 4 evidence (retrospective case series) with one representative of level 2 evidence (prospective cohort with comparison group). It was the conclusion of these authors that there is substantial evidence (level 4) with some stronger evidence that ESS is effective in improving quality of life in adult patients with CRS who are surgical candidates. These authors encouraged future investigators to focus on prospective studies and to include comparison groups in their study design.

In summary, then, the benefit of ESS in CRS, with or without polyposis, largely is accepted but primarily on the basis of uncontrolled studies. There is somewhat supportive evidence from four controlled studies demonstrating improvement versus baseline. Despite this relatively weak evidence, it is a commonly performed procedure, largely because of the potential risks of long-term steroid use and the lack of alternative effective medical therapies. Again, this is also the reason that most endoscopic sinus surgeons only would consider a patient to be a candidate for ESS after they have failed maximal medical therapy, in its current state of the art.

As surgeons, we are always cognizant that the procedure itself is not without risks, and once the decision has been made that a patient will benefit from ESS, the surgeon always considers the potential downside of the intervention, in particular the potential complications. Complications of ESS generally include potential orbital injuries, such as hematoma or extraocular muscle injuries, osteitis, and skull base injuries. All of these complications, fortunately, are rare. Nonetheless, one of the potential advantages of perioperative corticosteroids would be to reduce preoperative and intraoperative swelling and polyp load as well as reduce the degree of inflammation and, theoretically, blood flow or loss, thereby improving visualization of the surgical field and facilitating surgery. The use of corticosteroids perioperatively, however, is unproven and not without potential risks of its own.

**Perioperative Management for ESS**

Perioperative medical therapy in patients undergoing ESS is believed by many to be important, although there is considerable variability in actual practice based on published and survey data. Although many surgeons believe that routine postoperative care including endoscopic debridement optimizes surgical outcomes, the evidence is conflicting. In fact, in one study, 95.5% of 45 patients with refractory CRS achieved at least a 50% reduction in symptoms, despite a complete absence of postoperative care other than nasal doucheing with hypertonic saline after the 10th postoperative day. However, 10 patients were not assessed, having been lost to follow-up, and a 50% improvement in symptoms is less than that recorded in most ESS studies. Consequently, the general consensus appears to be that some perioperative management is indicated.

A significant body of literature exists examining various aspects of perioperative management, especially of postoperative management. These studies include clinical trials examining the effectiveness of perioperative antibiotics; mitomycin C (MMC); nasal packing; various wound dressing materials; the use of postoperative debridement; and counseling regarding cessation of smoking cigarettes. These studies have provided conflicting results.

With respect to MMC, for example, Chung et al. in a study of 55 patients undergoing bilateral ESS in whom a pledget soaked with 1 mL 0.04 mg/mL MMC randomly was applied to the infundibulum of one side and a similar pledget soaked in saline was applied to the other, unilateral adhesions were observed only in 3.6% of the MMC sides versus 14.5% of the saline sides, a result that almost achieved statistical significance ($P = .058$). Conversely, Anand et al. studied 24 patients undergoing bilateral ESS and observed seven (29.2%) cases of stenosis or synechia on the treated side and five (20.8%) on the untreated side, a difference that was not statistically significant. In view of the unknown long-term risks of administering an antineoplastic agent for non-neoplastic disease, this therapy has not gained wide popularity.

Also, with respect to postoperative nasal packing, Orlandi and Lanza, in a study of 169 ESS procedures on 165 patients with CRS, identified no significant risks associated with packing but also no clear benefits. There were no meaningful bleeding episodes (mean blood loss, 50 mL) in either the 19 procedures after which packing was used or the 147 procedures after which packing was not applied.

Two different preparations of hyaluronic acid (biocompatible, absorbable) dressing materials for use in ESS produced conflicting results in studies as well. In one study, Hylan B gel, applied randomly to one side in patients with bilateral ESS, resulted in less bleeding on the treated versus control side. Another study, using hyaluronic acid in a pliable sheet form, failed to show any difference between the treated and untreated sides over 8 weeks of follow-up. This was contrasted by another study that did demonstrate improved healing with hyaluronic acid stenting as compared with gelfilm.

The one controlled study that looked at perioperative use of antibiotics involved 202 patients, 101 of whom received cefuroxime axetil, 250 mg daily for 2 days, and the remainder receiving placebo. Over the duration of follow-up, there were no differences in any of 10 symptoms followed using a daily symptom diary, in 7 different measures assessed by endoscopy, or in the postoperative infection rate. One potential failing of this study was the short duration of therapy, which likely would not have been adequate to prevent or detect delayed superinfection or osteitis. Despite the lack of good evidence one way or the other, antibiotics often are espoused for use postESS, as are many of these...
other unproven but intuitively reasonable practices, demonstrating the importance and value of further controlled studies to generate more evidence-based practice.

Perioperative Corticosteroids for ESS
As already indicated, corticosteroids, in one form or another, often are part of standard medical management, and this often is continued throughout the perioperative period and beyond in patients undergoing ESS. However, this is not without risks because systemic corticosteroids not only reduce inflammation, they also generally impair immune responses, delay wound healing, and predispose patients to a variety of potentially serious side effects, some of which may occur acutely.

Moreover, a detailed Medline literature search, using various combinations of the search terms "steroid," "corticosteroid," "prednisone," "taper," and "tapering," failed to reveal any studies on or established guidelines for the tapering of postoperative corticosteroids, in any form and for any disease. Consequently, there appear to be tremendous fluctuations in how this is done.

The rationale for their use in the perioperative period, also as stated earlier, is that reduced inflammation in the operative field would intuitively be anticipated to improve visualization, reduce bleeding and related surgical complications, and result in improved healing, with less inflammation and less scarring. This all is unproven, however, which is the principal motivation behind the current study.

Mechanisms by Which Corticosteroids Work
Cortisone first was isolated from adrenal tissue by Mason et al.,115,116 in the 1930s. It was Hench et al.,117,118 however, who sparked interest in corticosteroids as a potential therapeutic agent, when they discovered their potent anti-inflammatory effects, a discovery that won these investigators a Nobel Prize in 1950. Unfortunately, it soon was discovered that the therapeutic use of corticosteroids was associated with a myriad of potential side effects, many quite unpleasant and many others potentially disfiguring or serious. After years of trial and error, the current state of the art for steroid use is to use as low a dose as possible, for as short a time as possible. Nonetheless, their use continues, in some instances, because they are life or limb saving. Moreover, many conditions, by their very nature, require the chronic use of corticosteroids. Until very recently, for example, chronic use of corticosteroids was the only therapeutic option available for patients with polymyalgia rheumatica and giant cell arteritis.119

There is no question that, except for treating patients who are adrenal insufficient, the therapeutic benefits of corticosteroids almost exclusively stem from their potent anti-inflammatory and immunosuppressant effects. These effects certainly are what are thought to be of advantage in the treatment of CRS and nasal polyposis.

The specific mechanisms by which corticosteroids work in general, or in particular in CRS and nasal polyposis, are unclear. What is known is that corticosteroids have a large variety of anti-inflammatory and immunosuppressant effects that inhibit both cascades at virtually all levels. They inhibit the migration of neutrophils and monocytes; presentation of antigen by macrophages to lymphocytes; lymphocyte proliferation, activation, and differentiation; and cytokine production and action.120–123 Virtually all species of lymphocytes appear to be sensitive to these inhibitory effects, including the T-lymphocyte subsets that appear to be predominant in CRS.

Recalling that CRS and nasal polyposis are both often associated with significant local and occasional systemic eosinophilia, corticosteroids also are potent inhibitors of eosinophils126 and have been used clinically to treat a variety of chronic inflammatory disorders associated with eosinophilia, including asthma,126,127 eosinophilia-myalgia syndrome,128 eosinophilic fasciitis,129 eosinophilic esophagitis,130 Churg-Strauss syndrome,131 hypereosinophilic syndrome,132,133 and chronic eosinophilic pneumonia.134

The primary advantages of corticosteroids in the management of CRS and nasal polyposis, therefore, are their potent anti-inflammatory and anti-immune effects, their easy delivery, and their generally very low monetary cost. As stated earlier, the mucosal edema, friability, and tissue hypertrophy present in CRS and nasal polyposis may contribute to decreased visualization within the surgical field, more significant bleeding, and an increased risk of surgical mishaps. Consequently, reducing this swelling/tissue hypertrophy potentially could improve both the ease of the operation and the ultimate outcome. In addition, reduced inflammation in the postoperative period may improve longer-term surgical outcomes. That corticosteroids can be delivered intranasally by a variety of means, including sprays and drops, facilitates their use, reduces the risk of systemic side effects (especially if used in low doses and for shorter periods of time), and, likely, improves patient compliance.135

Risks of Corticosteroid Use
For all their many uses and potentially life-saving effects, perhaps only narcotics and cancer chemotherapeutic drugs inspire more trepidation than corticosteroids, and justifiably so. The list of potential corticosteroid-related side effects is long and filled with many theoretically concerning effects, including Cushing’s syndrome; weight gain; truncal obesity; hypertension; various disfiguring skin changes; diabetes mellitus; increased risk of infections, including opportunistic infections; myopathy; osteoporosis; peptic ulcer disease; hyperlipoproteinemia and atherosclerosis; mood and mental changes; pancreatitis; and osteonecrosis.136 There are also a litany of short-term, nuisance side effects such as mood disturbances, gastric irritation, fluid retention, and increased appetite, which are reversible with cessation of the medications. With respect to their shorter, perioperative use, however, perhaps the side effects of greatest relevance and potential concern are 1) impaired wound healing; 2) immunosuppression with resultant increased infection risk; and 3) osteonecrosis, particularly avascular necrosis of the femoral head (hip).

Delayed wound healing. That cortisone causes detrimental effects on wound healing became evident as early as 1950 and 1951, when several different research
groups published the results of their studies.\textsuperscript{A137–A140} This is not surprising given the various skin manifestations observed with Cushing’s syndrome, including skin atrophy and striae.\textsuperscript{A136} The mechanisms of impaired wound healing appear to relate to the catabolic effects of cortisone and its analogs. These catabolic effects include protein breakdown; decreased new protein synthesis in various tissues including skin, muscle, bone, and connective tissue; and the inhibition of DNA synthesis and cell proliferation in various cell lines including fibroblasts.\textsuperscript{A141–A144} This all results in delayed formation of scar tissue and delayed epithelialization, an effect that can persist for up to 9 weeks after the drug has been withdrawn.\textsuperscript{A144} There are, however, potential mechanisms by which this impairment in wound healing can be, at least partially, reversed, including the use of vitamin A, anabolic steroids, growth hormone, and the tetrachlorodecaoxyanion anion complex.\textsuperscript{A145,A146} Despite this, the effect of intranasal steroids on wound healing never has been studied, nor have any studies addressed the potential effects of corticosteroids on wound healing in ESS. In fact, there are theoretic advantages to some impairment in wound healing with respect to the common dilemma of synechia formation post-ESS.

**Increased risk of infection.** Corticosteroids primarily benefit humankind because of their anti-inflammatory and immunosuppressive effects. However, as stated earlier, these effects are not targeted at any one facet of the immune system or inflammatory pathway. Corticosteroids globally inhibit both, which, at least theoretically, should result in an increase in the risk of infections. In fact, such an increase risk has been documented.\textsuperscript{A147,A148} This is worthy of some consideration in the postoperative period, both because of the increased risk of infections postoperatively and because of the adverse healing effects that wound infections cause.

As pertains to ESS, one recent study undertook intraoperative cultures from the nasal vestibule, middle meatus, ethmoid lining, and peripheral blood during and after ESS in patients with CRS.\textsuperscript{A149} The investigators found that approximately 30% of the patients had sterile sinususes, 50% had coagulase-negative staphylococci, and the remainder had a mixed group of “nonpathogenic” organisms. Anaerobes were conspicuously rare. In addition, blood cultures were positive in 7% of cases and were consistent with an organism already identified at the operative site.

Whether an increase in infection risk would occur with the use of intranasal steroids is not clear. In general, lower doses of corticosteroids do not appear to increase infection risk,\textsuperscript{A147,A151} and the short-term, perioperative use of these medications in an otherwise immunocompetent host does not intuitively appear risky. So far, virtually all the research demonstrating an increased infection risk caused by corticosteroids was performed on patients with autoimmune rheumatic diseases, which are, in themselves, associated with significant alterations in immune status, even untreated, and with an increased risk of infections.\textsuperscript{A151,A152} That the same level of risk would occur in patients with CRS, even at higher doses of steroids, is unlikely, but not known. One should recognize that, although relatively little intranasal drug is absorbed systemically, at least compared with oral preparations, nonetheless, there is some absorption via this route, a phenomenon that has led to the development of several intranasally delivered drugs for the treatment, for example, of refractory migraines. Moreover, even if the amount of steroid delivered systemically is relatively small and unlikely to precipitate systemic or peripheral infections, nonetheless, the risk of local infection and its effect on clinical outcome cannot be completely ignored. Nevertheless, it can be generally summarized that topical intranasal steroids likely have a negligible risk of immune suppression, something that may not be the case with systemic steroids.

**Osteonecrosis.** Avascular necrosis of the hip is one of the classic, acute catastrophic consequences of corticosteroid use, most commonly at higher doses.\textsuperscript{A153,A154} Unlike osteoporosis, which only develops after at least 3 months of therapy and usually only after much longer than that,\textsuperscript{A155} osteonecrosis has been observed as early as 7 days after initiation of steroid therapy, albeit only very rarely and generally only with higher doses.\textsuperscript{A136} Moreover, steroid-induced osteonecrosis can involve both hips or several other joints as well, with involvement particularly in the femoral heads and condyles, the humeral heads, and the talus.\textsuperscript{A136,A146}

Osteonecrosis of the hip has been subdivided into five clinical stages, numbered from 0 to IV, as part of the Association Research Circulation Osseous international classification criteria.\textsuperscript{A157} Early detection is important, most easily by means of magnetic resonance imaging. Treatment includes immediate cessation of steroids and supportive measures. Although traditional thinking holds that osteonecrosis develops secondary to a hypercoagulable state with impaired fibrinolysis,\textsuperscript{A158} recent evidence has suggested that corticosteroid induced adipogenesis in bone marrow may contribute to osteonecrosis and that the statin class of cholesterol-lowering medications may be helpful in preventing steroid induced osteonecrosis.\textsuperscript{A159,A160} Unfortunately, many patients with hip disease ultimately require total hip arthroplasties. Patients with involvement of other joints sometimes require joint fusion.\textsuperscript{A157}

When corticosteroids are considered in the context of short-term use in patients with CRSwP, the literature does give one cause for reflection. A case series published by McKee et al.\textsuperscript{A161} documented 15 cases of osteonecrosis of the femoral head in men after short-course systemic steroid therapy. The mean duration of therapy in these patients was 21 days, with a 16 month mean lag time between steroid administration and development of hip symptoms. There was a notable lack of other risk factors in these patients except for in three of them, (alcoholism in two and diabetes mellitus in one). It is important to note that this was a retrospective review of all patients presenting with femoral head necrosis over a 10 year period. These patients’ charts were reviewed, and those who had received a single, short course of corticosteroids within 3 years of presentation were selected out for analysis. In addition to this weakness, the authors also did not provide the total number of patients who presented with osteonecrosis of the femoral head during the same time. To date, there are no data on the risk of osteonecrosis with intranasal use of steroids or with ESS.
Clearly, systemic steroids have significant advantages in many disease states including CRS, but this is counterbalanced by the not-insignificant associated side effects. Common sense on the part of clinicians as well as published recommendations propose that systemic corticosteroids be used in situations where the indications are solid, the evidence for their efficacy is accepted if not proven, and the medical comorbidities are taken into account.\textsuperscript{162}

Objectives of Current Research

CRS is an inflammatory disease of the sinonasal tract that is of multifactorial etiology and complex classification. Management of this complex disease is primarily medical, with pharmacotherapy achieving control of symptoms in the majority of situations. However, a sizeable population of patients with this disease fails to achieve control with medical therapy, and, in many cases, surgery is both required and helpful in providing long-term control of patient symptoms as well as the objective disease process. A sizeable pool, albeit mostly uncontrolled, of data exists that demonstrates surgery to be beneficial; however, there is considerable variability in the perioperative management of patients undergoing ESS.\textsuperscript{103} This variability primarily is related to a general lack of evidence on which to base practice.

Patients undergoing ESS for treatment of chronic sinusitis with polyposis often present technical challenges with respect to operative blood loss and intraoperative visualization. In addition, surgical edema and recurrent polyps are postoperative challenges that can and do compromise surgical outcomes (subjective as well as objective).

Theoretically, systemic steroids could help to mitigate these problems by reducing overall inflammation, thus facilitating removal of polyps, reducing intraoperative bleeding, and improving visualization and completeness of surgery. In addition, one can hypothesize that improved patient outcomes would result because of reduced inflammation in response to the surgical insult, reduced scarring, and possibly a faster return to normal sinus physiology and mucociliary clearance.

General Objective 1

The primary objective of the current research, therefore, is to conduct a randomized, double-blind, placebo-controlled study that will assess the effect of perioperative systemic corticosteroids on both subjective and objective outcomes in patients undergoing ESS for CRSwP. The impact of this medication will be examined during both the operative and postoperative periods. The choice of outcome measures to be used for this study was considered carefully because there are many from which to choose, including the following.

Published Outcome Measures for CRS and Nasal Polyposis

Subjective measures:

- SF36
- SNOT-16
- SNOT-20
- Chronic Sinusitis Survey (CSS)
- 31-Item Rhinosinusitis Outcome Measure (RSOM-31)
- Rhinosinusitis Quality of Life Survey (RQLS)
- Rhinoconjunctivitis Quality of Life Questionnaire (RQLQ)
- Rinosinusitis Disability Index (RSDI)
- Sinonasal Assessment Questionnaire (SNAQ-11)

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7 to 8 weeks. Despite the limitation of few items, the CSS has numerous advantages. It is very easy to comprehend and complete, usually taking less than 1 minute for patients to complete, and it is also very easy to score. It has a high degree of test-retest reliability and content validity\(^A_{170}\) and appears to be very sensitive to change after treatment.\(^A_{165,171}\) It even has been translated into other languages, including a Chinese version that has been scientifically validated.\(^A_{166}\) For these reasons, it has been used in a considerable number of CRS studies.\(^A_{12,165,167,172–179}\)

Several other subjective outcome scales, such as the RSOM-31\(^A_{180}\) and SNOT-20\(^A_{181}\) may have too many items to be convenient, both for the patient and for the person scoring or interpreting them. The former has 31 items subdivided into seven domains: nasal, eye, sleep, ear, general, practical, and emotional. For each item, there are two rating scales; patients rate each item both with respect to the magnitude or severity of the problem and with respect to the importance of the problem. For example, someone might report chronic severe rhinorrhea (magnitude high), but this symptom may not interfere much with their quality of life (importance low). The product of magnitude and importance creates an overall symptom impact score. Consequently, this instrument provides considerable detail, which may be useful in certain settings. However, the instrument essentially asks 62 questions and takes approximately 20 minutes to complete. Also, measures that have many diverse domains tend to be relatively insensitive to change. For this reason, although used in some studies,\(^A_{182,183}\) the RSOM-31 has not been as widely used as some other instruments.

Despite, or perhaps because of, its rather ironic name, the SNOT-20 has been more popular.\(^A_{15,172,176,184–188}\) In fact, it is a reduced form of the RSOM-31 and was developed and validated by the same team that developed the earlier instrument.\(^A_{181}\) The SNOT-20 was created by eliminating the 11 items deemed least clinically relevant or psychometrically valid. It retains the magnitude and importance rating scales given in the RSOM-31; therefore, it entails 40 actual questions. Oddly, however, all questions on nasal congestion, the most common major symptom in CRS and nasal polyposis,\(^A_{11}\) were eliminated, and so were questions on olfactory function. Moreover, its sensitivity to change appears to be less than the CSS, again, perhaps because of the greater number of items examining more domains, and also less than the RSOM-31.\(^A_{181}\) Scores on the SNOT-20 also do not correlate at all with CT findings.\(^A_{184}\)

A shorter version yet, the SNOT-16,\(^A_{184}\) was developed, but it has not gained much use. Interestingly, although it has not received much attention or use, the SNOT-16 also appears to be more sensitive to change than the SNOT-20.\(^A_{183}\)

The other symptom and quality of life scores, such as the RQLS,\(^A_{172}\) the RQLQ,\(^A_{189}\) the RSDI,\(^A_{190}\) and the SNAQ-11,\(^A_{188}\) have received far less use and attention than the CSS or SNOT-20. The RQLQ particularly is designed for patients with allergic rhinosinusitis,\(^A_{189}\) which constitutes only a subset of all CRS patients; consequently, the instrument is not useful in most CRS studies.

**Objective Measures of CRS**

Just as there have been numerous proposed measures of subjective status for patients with CRS and nasal polyposis, several investigators have proposed their own staging or grading systems by which to assess the degree of objective disease in patients with CRS. These include systems proposed by Friedman et al.,\(^A_{191}\) Kennedy,\(^A_{192}\) May et al.,\(^A_{193}\) Gliklich and Metson,\(^A_{194}\) Jorgensen,\(^A_{195}\) Newman et al.,\(^A_{196}\) and Lund and MacKay.\(^A_{197}\)

Of the seven proposed systems, the first four are global measures, all rating from stage 0 to stage IV, indicating increasing extent of disease on CT imaging. For example, Gliklich and Metson’s stage 0 refers to diffusely normal tissue; stage I refers to unilateral disease; stage II to limited bilateral disease; stage III to more extensive bilateral disease; and stage IV to pansinusitis.

The last three systems rate each sinus separately, both on the left and right, and then provide a global score. Jorgensen’s system rates the degree of opacification, the size of polyps, and the degree of occlusion.\(^A_{185}\) Lund and MacKay’s system is simpler, only rating degree of opacification as absent (0), partial (1) or complete (2), except for the ostiomeatal complex, for which either a rating of 0 (not occluded) or 2 (occluded) is assigned.\(^A_{197}\) Newman et al.’s system, perhaps, is the most objective, actually measuring mucosal wall thickness and assigning ratings between 0 (0–1 mm thick) and 3 (>9 mm thick), as well as degree of occlusion, again rated from 0 to 3.\(^A_{196}\)

The latter three systems obviously provide more information, but there is no evidence that any one system is better than any other. However, the Task Force on Rhinosinusitis, as opposed to having no preference in subjective measures, did have a preference for the Lund-MacKay staging system, perhaps because it is simpler than either the Jorgensen or Newman et al. systems, and its measures appear to be less subject to variance in operator interpretation.\(^A_{197}\) Perhaps because of this recommendation, the Lund-MacKay system has been, by far, the most widely used system, especially in recent years.\(^A_{22,190,175,176,182,184,188,198–206}\) It also has been scientifically validated,\(^A_{194}\) tested in non-CRS patients,\(^A_{196}\) and is both highly reproducible\(^A_{205}\) and sensitive to change posttreatment.\(^A_{196,200,201}\) Unlike the other scales, it has been tested in children.\(^A_{203}\) In addition, the Lund-MacKay staging system may be more popular because it incorporates additional data such as a visual analogue scale for symptoms (Sinus Symptom Questionnaire [SSQ]) and the more recent Kennedy-Lund modification to include an endoscopic scoring system. Such “one-stop shopping” make it simpler to collect data in outcomes studies of CRS. On the other hand, the Lund-MacKay CT scoring scheme alone does not correlate with levels of symptoms or quality of life scores\(^A_{175,184}\) and does not predict symptomatic improvement postESS.\(^A_{200}\)

**Endoscopic Evaluation of ESS and Nasal Polyposis**

If seeing is believing, then it makes sense that endoscopy is the gold standard for evaluating the nose and
sinuses. Interestingly, there is rather limited literature validating any staging system for ESS based on or including endoscopy. However, as mentioned above, Lund and MacKay have developed a global evaluation tool that combines symptoms, CT appearance, and endoscopic appearance (with the Kennedy-Lund modification) into one instrument. Although there is no global score, the tools are, nonetheless, intended for use in conjunction with each other. The SSQ consists of seven visual analogue items, each of which is scored from 0 to 10. Each of the following symptoms is assessed by the items: nasal blockage/congestion; headache; facial pain; loss of sense of smell; nasal discharge/postnasal drip; sneezing; and overall symptoms.

The Lund-MacKay Staging Scale uses CT images, as described earlier. In addition, an endoscopic scale has been developed for inclusion in the system, which assesses certain characteristics in each sinus on each side, including whether polyps are absent (score = 0) or present either in the middle meatus only (1) or beyond the middle meatus (2); whether there is edema, scarring, or crusting, each being rated as absent (0), mild (1), or severe (2); and whether there is discharge, being rated as absent (0), clear and thin (1), or thick or purulent (2). This endoscopic scoring system was added to the revised staging system for rhinosinusitis described by Lund and Kennedy.\(^\text{207}\)

Other advantages to the Lund-Kennedy modification of the Lund-McKay system are the inclusion of patient demographic data as well as surgical score (extent of surgery) and documentation of associated medical conditions (e.g., asthma). For an outcomes study such as the present one, which focuses on operative and postoperative outcomes, this staging system is ideal and was therefore chosen from among the others available. With clarification of the outcomes measures available as outlined above, the primary objective of the study can now be stated as three specific subjectives, which are as follows.

**Objective 1A.** To assess the effect of perioperative prednisone versus placebo with respect to operative parameters of the technical aspects of surgery (e.g., ease of surgery, blood loss, operative time).

**Objective 1B.** To assess the effect of perioperative prednisone versus placebo with respect to changes in the seven subscales of the SSQ and the SSQ summation score.

**Objective 1C.** To assess the effect of perioperative prednisone versus placebo with respect to changes in the total Lund-Kennedy Endoscopy Scale (LKES).

**Perioperative Sinus Endoscopy Score (POSE Score)**

As part of the current research project, the author developed a novel endoscopy rating scale, which is to be tested against the currently used LKES. Similar to the Lund-Kennedy instrument, this scale assesses for various findings within the sinuses, including synchiea, obstruction, crusting, edema, polypoid change, polyps, and purulence. Unlike the Lund-Kennedy instrument, the POSE rates sinuses individually, specifically assessing the following anatomic areas: 1) the middle turbinates; 2) the middle meatus; 3) the ethmoid cavity; 4) the frontal recess/sinus; and 5) the sphenoid sinus. Not all features are examined in every area, only those deemed pertinent to the area being examined, so as to make the instrument less cumbersome. It was the author’s intent that this endoscopy scale, because it is more detailed and specific, be highly reproducible, sensitive to change related to treatment, and to perhaps correlate more strongly with symptoms than the LKES. The second objective of this project, therefore, was as follows.

**General Objective 2**

The second general objective is to compare the newly developed POSE system with the Lund-Kennedy scale and to determine whether the new scale offers any advantages over the older, more-established instrument. This second objective can and should be stated more specifically. To do so, it must be broken down into the following specific objectives.

**Specific objective 2A.** To compare the POSE score with the LKES in terms of sensitivity to change during ESS postoperative follow-up in patients with CRSwP.

**Specific objective 2B.** To determine the degree of correlation between change in POSE score and change in symptom severity, both as measured using the Lund-McKay SSQ and the CSS.

**Specific objective 2C.** To estimate the levels of correlation between the POSE and the LKES and the levels of correlation between changes in the POSE and the LKES.

**Specific objective 2D.** To estimate the predictive power of the POSE score used 2 weeks Post-ESS as a tool to predict long-term response to ESS in patients with CRSwP.

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**TABLE A1.**

Summary of Scoring Criteria for Peri-Operative Sinus Endoscopy (POSE) Score.

<table>
<thead>
<tr>
<th>Middle Turbinate</th>
<th>Synechia/Lateralized</th>
<th>Synechia to lateral wall or Lateralized MT = 1 point each</th>
<th>Middle Meatus/MMA</th>
<th>Score = 1</th>
<th>Score = 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Narrowing/Closure</td>
<td>MMA narrow (scar or edema)</td>
<td>MMA closed (scar or edema)</td>
<td>Maxillary Sinus Contents</td>
<td>Mucoid secretions/edema</td>
<td>Purulence/allergic mucin</td>
</tr>
<tr>
<td>Ethmoid Cavity</td>
<td>Crusting</td>
<td>Mild (few isolated)</td>
<td>Extensive (diffuse or occluding)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mucosal Edema</td>
<td>Loss of discernible underlying bony contours in some areas</td>
<td>Diffuse loss of discernible underlying bony contours</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Polypoid Change</td>
<td>Discernible outpouchings beginning to narrow or partly fill the cavity</td>
<td>Discernible outpouchings fill the ethmoid cavity</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Polyposis</td>
<td>Extending beyond middle meatus but not to the inferior turbinate</td>
<td>Beyond the upper border of the inferior turbinate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secretions</td>
<td>Thin/mucoid</td>
<td>Purulent/allergic mucin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary Sinuses</td>
<td>Frontal Recess/Sinus</td>
<td>Narrowed/edema present</td>
<td>Obstructed/infected/severely inflamed</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sphenoid Sinus</td>
<td>Narrowed/edema present</td>
<td>Obstructed/infected/severely inflamed</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For purposes of establishing baseline the operative findings can be used to calculate the score. For MT a paradoxical curvature can be scored as 1 point (i.e. lateralized). For most other aspects of the scoring system the findings at surgery are the same as post-operatively. It can also be applied to primary and to revision surgeries.