

# Comparison of Swabs versus Suction Traps for Endoscopically Guided Sinus Cultures

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## ABSTRACT

**Background:** Knowledge of the causative organism(s) in bacterial rhinosinusitis has become the cornerstone of adequate medical and surgical management. Little uniformity and data exist for the best method of obtaining sinus cultures. Most otolaryngologists tend to use the nasal swab for obtaining transnasal middle meatal cultures. A prospective study was carried out to compare the effectiveness of standard nasal swabs versus suction traps in obtaining bacterial isolates under endoscopic guidance.

**Methods:** Fifty-two patients with purulence in the middle meatus or frontal recess were included in the study. All patients were cultured using nasal wire swabs. Twenty-five of these patients also had the purulence suctioned into a Xomed Sinus Secretion Collector (XSSC) (Xomed Surgical Products, Jacksonville, FL), and 27 patients had the purulence suctioned into a standard Leukens trap (Busse Hospital Disposables, Hauppauge, NY). All specimens were sent to the hospital microbiology laboratory within 1 hour of capture.

**Results:** The average number of bacteria cultured per patient was 1.21 for the swab, 1.37 for the XSSC trap, and 1.08 for the Leukens trap. The agreement between bacteria captured from the wire swab and suction trap was 76.9%, with significant agreement being observed by all isolates with the exception of coagulase-negative *Staphylococcus* and the other gram-positive bacteria group consisting of *Streptococcus viridans*,  $\beta$ -hemolytic streptococcus, and  $\alpha$ -hemolytic streptococcus.

**Conclusion:** This study suggests that the wire swab appears to be as efficacious at obtaining endoscopically guided cultures as the Xomed and Leukens suction devices.

## SOMMAIRE

**Introduction:** La connaissance sur les organismes bactériens causant la rhino-sinusite est devenue la pierre angulaire d'une gestion médicale et chirurgicale adéquate. Peu d'uniformité et de donnée existent quant à la meilleure méthode d'obtenir des cultures de sinus. La plupart des oto-rhino-laryngologistes ont tendance à utiliser l'écouvillon nasal pour obtenir une culture méatale transnasale. Une étude prospective a été effectuée pour comparer l'efficacité d'un écouvillon nasal standard par rapport à une trappe pour obtenir l'échantillon sous guidance endoscopique.

**Méthodes:** Cinquante-deux patients avec du pus dans le méat moyen ou le récessus frontal ont été inclus dans cette étude. Tous les patients ont eu une culture nasale utilisant un écouvillon sur tige. Chez vingt-cinq de ces patients le pus a été succionné dans un Xomed Sinus Secretion Collector (XSSC) (Xomed Surgical Products, Jacksonville, FL) et pour les 27 autres on a utilisé une trappe Leukens régulière. Tous les spécimens ont été envoyés au laboratoire de microbiologie de l'hôpital à l'intérieur d'une heure du prélèvement.

**Résultats:** Le nombre moyen de bactéries par culture par patient était de 1.21 pour l'écouvillon, 1.37 pour la trappe XSSC, et 1.08 pour la trappe Leukens (Busse Hospital Disposables, Hauppauge, NY). La cohérence entre les bactéries cultivées avec l'écouvillon sur tige et la trappe à suction était de 76.9%, avec un accord significatif pour chaque isolat à l'exception du *Staphylocoque* coagulase négative et l'autre groupe bactérien gram-positif formé du *Streptocoque viridans*, du streptocoque  $\beta$ -hemolitique, et du streptocoque  $\alpha$ -hemolitique.

**Conclusion:** Cette étude suggère que l'écouvillon apparait être aussi efficace pour obtenir des cultures sous direction endoscopique que les appareils à suction Xomed et Leukens.

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Using a culture-directed antibiotic for the treatment of acute and chronic sinusitis has become the cornerstone of medical management for bacterial rhinosinusitis. Several studies have concluded that endoscopic cultures done from the middle meatus using an aseptic technique give valuable information with respect to pathogenic organisms within the sinuses. Good correlation has been demonstrated between organisms obtained endoscopically from the middle meatus and those in an infected sinus.<sup>1-3</sup>

Most otolaryngologists use a swab-like device under endoscopic guidance to obtain a sample from an infected middle meatus, and most authors who have written on the subject have used swabs to determine the causative pathogens. Vaidya and colleagues and Chow and colleagues, among others, have investigated the use of swabs in acute sinusitis,<sup>4,5</sup> whereas Bolger, Nadel and colleagues,<sup>6</sup> and Klossek and colleagues have reported results from patients with chronic sinusitis using the same technique.<sup>3,6,7</sup> Nadel and colleagues and Klossek and colleagues have also reported on the resident flora of the healthy adult middle meatus using nasal swabs.<sup>8,9</sup> A significant amount of knowledge and understanding therefore exists regarding the commensal and pathogenic flora of the middle meatus in normal subjects and bacterial rhinosinusitis patients when a swab-like device is used to capture the mucopurulence.

Two basic trap types, the wire swab and the Leukens suction trap (Busse Hospital Disposables, Hauppauge, NY), have been available for the acquisition of purulent material from the nose. Recently, a new trap type, the Xomed Sinus Secretion Collector (XSSC) (Xomed Surgical Products, Jacksonville, FL), another suction trap with modifications, has become available for aspirating mucopurulence from narrow passages in the nose and sinus drainage pathway. Samples were obtained using an aseptic technique under endoscopic guidance. The aim of this study was to directly compare the efficacy of the wire swab with the Leukens suction trap and the XSSC in isolating bacteria in chronic bacterial rhinosinusitis patients.

## Materials and Methods

Adult patients, at least 18 years old, presenting to a tertiary sinus centre with chronic bacterial rhinosinusitis were offered the opportunity to participate in the study. After obtaining approval from the local Institutional Review Board, 52 patients were included in the study. The sampling method was explained, and patients' consent was obtained. A complete history and otolaryngologic physical examination, including a rigid sinonasal endoscopic examination of the middle meatus and frontal recess, was performed. Information was recorded on a data collection form that included the patient's age, sex, history of antibiotic use, previous sinus surgeries, side and site of the sinus cultured, and endoscopic findings. Most patients had digital endoscopic pictures taken of the cultured site. Subjects were excluded from the study if they had received systemic or local antibiotics within the 3 weeks preceding

the study or patients with acute rhinosinusitis. All patients had chronic bacterial rhinosinusitis with acute exacerbations. Patients without purulence on endoscopy were not included in the study.

Nasal endoscopy was performed with a 2.7 or 4.0 mm 30° and/or 70° rigid nasal endoscope. The nose was not sprayed with a decongestant or analgesic prior to endoscopy in most cases. Decongestant nasal spray was used only if it was felt that the passageway to the site of interest (middle meatus or frontal recess) was too narrow to allow safe passage of the wire swab without contamination from the nasal mucosa. The middle meatus and frontal recess were examined. If purulence was noted in the middle meatus, at the maxillary sinus outflow tract, within a marsupialized sinus cavity, or in the frontal recess, then cultures were obtained. A sterile "micro" wire swab (Starplex Scientific Inc, Etobicoke, ON) was introduced into the nasal cavity under endoscopic visualization with minimal contamination from the vibrissae or nasal mucosa. The swab was placed in the purulence for a few seconds until moist and then carefully removed. The swab was immediately placed into a Starplex Microorganism Collection and Transport System (Starplex Scientific, ON) for Gram stain and culture. Immediately following this, one of the suction traps, either an XSSC, which was provided by Medtronic-Xomed, or a Leukens trap, was placed into the nose under endoscopic visualization. The purulence from the exact site that had been previously swabbed was then aspirated into the suction trap. The trap was removed from the suction apparatus and sent to the hospital microbiology laboratory for routine Gram stain and aerobic, anaerobic, and fungal cultures within 1 hour of capture. Antibiotic sensitivities were also requested for all samples. All patients acted as their own control owing to collecting the wire swab and suction trap samples from the same site of each patient.

All samples were Gram stained and inoculated onto Columbia agar plates with 5% sheep blood, chocolate agar plates, and MacConkey agar plates. These plates were incubated in 5% CO<sub>2</sub> at 35°C. Anaerobic culture was performed by inoculating samples onto *Brucella* blood agar plates with hemin and vitamin K and colistin-nalidixic acid agar plates. Both were incubated in anaerobic jars at 35°C. Fungal culture was performed by inoculating samples onto an inhibitory mould agar slant (containing chloramphenicol) and a brain heart infusion slant (containing 5% sheep blood, chloramphenicol, and gentamicin). Both slants were incubated at 30°C in ambient air. Isolates were identified by standard methods.<sup>10</sup> Bacteria that grew on culture were reported semiquantitatively for

each specimen submitted with the following scale: 1+, few; 2+, moderate; 3+, heavy growth. Cultures were read at 24 and 48 hours and again on days 3, 4, and 5 if negative. Antibiotic susceptibility testing was performed according to National Committee for Clinical Laboratory Standards.<sup>11,12</sup> This procedure for culturing and antibiotic sensitivity identification was routine (not experimental) for the hospital laboratory. Coagulase-negative staphylococci, *Staphylococcus aureus*, and diphtheroids were considered commensal flora or nasal contaminants unless they grew in concentrations of 3+ or more.

Culture results were analyzed for agreement between the swab and the suction devices. Samples were considered strong correlates if the same bacterial organisms were recovered in a similar quantity. Samples were considered moderate correlates if the predominant organism recovered with the wire swab was also recovered with the suction trap but an additional organism was recovered by one of the two capture methods. Samples were considered noncorrelates if the predominant organisms recovered by the two capture techniques under comparison differed.

The wire swab versus suction trap bacterial culture results were compared using mean score, as well as agreement in organisms captured and concordance analysis. Bacterial isolates were divided into seven groups, and concordance analysis was performed by our statistician using the Cohen kappa statistic. The seven groups were broken down as follows: group 1 contained coagulase-negative *Staphylococcus* (SCN); group 2, *S. aureus*; group 3, diphtheroids; group 4, bacteria commonly associated with gram-negative sinusitis, including *Pseudomonas aeruginosa*, *Neisseria* sp, *Stenotrophomonas maltophilia*, *Haemophilus influenzae*, *Proteus mirabilis*, *Moraxella catarrhalis*, *Enterobacter cloacae*, *Agrobacterium radiobacter*, *Serratia marcescens*, *Klebsiella pneumoniae*; group 5, *Streptococcus pneumoniae*; group 6, other gram-positive bacteria, including *S. viridans*,  $\beta$ -hemolytic streptococcus, and  $\alpha$ -hemolytic streptococcus; and group 7, no bacteria growth.

## Results

Fifty-two patients participated in the study. The mean age was 50.4 years (range 18–81 years). Twenty-seven men and 25 women were included in the study group. Most patients had previous sinus surgery, with an average of 1.7 surgeries per patient. No statistical difference was found for the above demographics between patients cultured with the Leukens or the XSSC trap. Culture results can be found in Table 1. The average number of total bacterial isolates cultured per patient was 1.21 for the wire swab versus 1.37

**Table 1.** Culture Results

Organism	Swab	Suction Trap
Total cultures	63	64
<i>Staphylococcus aureus</i>	8	7
<i>Streptococcus pneumoniae</i>	3	3
SCN	26	17
<i>Staphylococcus viridans</i>	2	5
<i>Streptococcus anginosus</i>	1	0
$\beta$ -Hemolytic streptococcus	1	1
$\alpha$ -Hemolytic streptococcus	1	1
Diphtheroids	5	4
Gram-negative sinusitis	16	26
No growth	6	7

SCN = coagulase-negative *Staphylococcus*.

for the XSSC trap (25 patients) and 1.08 for the Leukens trap (27 patients). Taking into account that SCN was considered commensal flora unless it grew in concentrations  $\geq 3+$ , the average number of pathogenic bacterial isolates cultured per patient was 0.60 from the wire swab, 1.05 for the XSSC, and 0.78 for the Leukens trap. Twenty-one (40%) samples cultured using the wire swab demonstrated no growth or commensal growth only. Fifteen (29%) samples cultured using the suction traps demonstrated no growth or commensal growth only. When all bacteria were included, an agreement rate of 76.9% was observed between bacteria isolated by the wire swab and bacteria isolated by the suction traps.

### Coagulase-Negative *Staphylococcus*

Using the wire swab, we retrieved light (+1) or moderate growth (+2) of SCN in 25 of 52 (48.0%) isolates and heavy growth in 1 of 52 isolates (1.9%), for a total of 26 isolates (50%). The XSSC cultured light (+1) or moderate growth (+2) of SCN in 8 of 25 isolates (32.0%) and heavy growth in none of the isolates. The Leukens trap retrieved SCN in 9 isolates (8 light or moderate growth, 1 heavy growth), for a total of 33.3% of samples (Table 2). Heavy growth of SCN retrieved from the Leukens trap corresponded accurately to the heavy growth obtained by the swab. The concordance of SCN isolated from the wire swab and SCN isolated from the suction trap resulted in a kappa value of 0.45 (Table 3).

### *Staphylococcus aureus*

*S. aureus* was isolated from all three capture methods. The wire swab isolated *S. aureus* in eight isolates (three light/

**Table 2.** Gram-Negative Sinusitis Bacteria

Organism	Swab	Suction Trap
<i>Pseudomonas aeruginosa</i>	2	3
<i>Stenotrophomonas maltophilia</i>	2	3
<i>Haemophilus influenzae</i>	8	10
<i>Proteus mirabilis</i>	1	1
<i>Moraxella catarrhalis</i>	2	5
<i>Enterobacter cloacae</i>	1	2
<i>Agrobacterium radiobacter</i>	0	1
<i>Serratia marcescens</i>	0	1

moderate growth, five heavy growth), for a total of 15.4% of samples. The Leukens trap did not isolate light (+1) growth in any culture samples but isolated moderate growth (+2) in 1 of 27 isolates (3.7%). Heavy growth was isolated in 4 of 27 isolates (14.8%), for a total of 18.5% of isolates. Isolates obtained from the Leukens trap corresponded accurately with all isolates recovered from the swab at the same site of capture. The XSSC cultured light growth (+1) or moderate (+2) growth of *S. aureus* in 2 of 25 isolates (8.0%). Heavy growth was not captured in any isolate. Light (+1) and moderate (+2) growth of *S. aureus* captured by the XSSC corresponded accurately with the wire swab in both isolates. The concordance rate of *S. aureus* isolated from the wire swab and suction traps resulted in a kappa value of 0.72 (see Table 3).

### Diphtheroids

Diphtheroids were isolated by the wire swab in 5 of 52 isolates (4 light/moderate growth, 1 heavy growth), for a total capture rate of 9.6%. The Leukens traps captured diphtheroids in three isolates (two light or moderate

growth, one heavy growth), for a total capture rate of 11.0%. Two strong correlations and one noncorrelation were observed between the Leukens trap and the wire swab. Xomed traps isolated diphtheroids in 1 of 25 patients (one heavy), for a capture rate of 4.0%. Moderate correlation was seen between the single wire swab isolate and the Xomed trap isolate. The level of concordance for isolating diphtheroids between the wire swab and the suction traps was moderate at 0.64 (see Table 3).

### Gram-Negative Sinusitis

Gram-negative cultures consisting of *P. aeruginosa*, *Neisseria* sp, *S. maltophilia*, *H. influenzae*, *P. mirabilis*, *M. catarrhalis*, *E. cloacae*, *A. radiobacter*, *S. marcescens*, and *K. pneumoniae* were isolated with all three capture methods (see Table 2). The wire swab isolated gram-negative bacteria in 16 isolates, with one culture isolating two gram-negative bacteria, for a total of 30.8% of isolates. The XSSC captured gram-negative bacteria in 13 isolates, with two cultures isolating two and one culture isolating three gram-negative bacteria. The Leukens trap isolated gram-negative bacteria in 13 cultures, with one culture isolating two gram-negative bacteria, for a total of 48.1% of gram-negative isolates. Agreement was observed between the wire swab and the suction traps in 64% of gram-negative bacteria isolated. The concordance between bacteria commonly associated with gram-negative sinusitis isolated from the wire swab and the suction trap was 0.72 (see Table 3).

### *Streptococcus pneumoniae*

*S. pneumoniae* was isolated by the wire swab in 3 of 52 cultures (5.7%). The XSSC isolated *S. pneumoniae* in 1 of 25 cultures (4.0%). The Leukens trap isolated *S. pneumoniae* in 2 of 27 cultures (7.4%). A strong correlation between the wire swab and the suction trap was observed for all three isolates of *S. pneumoniae*. The concordance between *S. pneumoniae* isolated from the wire swab and the suction traps was 1.0 (see Table 3).

### Gram-Positive Bacteria

Gram-positive bacteria consisting of; *S. viridans*,  $\beta$ -hemolytic streptococcus, and  $\alpha$ -hemolytic streptococcus were isolated with all three capture methods. The wire swab isolated these gram-positive bacteria in 5 of 52 cultures (9.6%). The XSSC isolated these gram-positive bacteria in 2 of 25 cultures (8.0%). The Leukens trap

**Table 3.** Concordance

Organism	$\kappa$
SCN	0.45
<i>Staphylococcus aureus</i>	0.72
Diphtheroids	0.64
Gram-negative sinusitis	0.72
<i>Streptococcus pneumoniae</i>	1.0
Gram-positive bacteria	0.39
No growth	0.74

SCN = coagulase-negative *Staphylococcus*.

isolated these gram-positive bacteria in 5 of 27 cultures (18.5%). A moderate correlation was observed between the wire swab and suction traps in 33% of these gram-positive bacteria. The concordance observed between the capture methods of these gram-positive bacteria was 0.39 (see Table 3).

### No Growth

No growth was obtained in six patients cultured by the swab and six patients cultured with the XSSC (see Table 2). Correlation of no growth between five of six patients was seen when swab and XSSC samples were taken from the same site. The remaining patient who failed to isolate growth from the XSSC trap grew (+1) SCN from the same site using the swab. Only one patient failed to grow bacteria with the Leukens trap when no growth was seen with the swab. The concordance rate between no growth of bacteria observed in the wire swab and no growth of bacteria observed in the suction trap was 0.74 (see Table 3).

### Discussion

An ongoing concern with endoscopically guided cultures is the recovery of normal nasal flora and subsequent false-positive diagnosis of sinusitis or treatment of nonpathogenic bacteria. Similarly, another concern is the inability to detect the causative organism, thereby resulting in inadequate therapy. When patients with chronic bacterial rhinosinusitis are cultured, it is important to use the most efficacious method available in identifying the pathogenic organism(s) so that appropriate culture-directed treatment can be instituted. The ideal culturing technique should be easily tolerable and be able to most accurately identify the pathogenic bacteria in the sinus drainage pathways, with a minimal risk of contamination by commensal flora. The current technique of using swabs for culturing the middle meatus under endoscopic guidance has been accepted as adequate when compared with antral puncture cultures.<sup>1,4</sup> Gold and Tami carried out aspiration culture from the middle meati during surgery and compared it with antral cultures obtained via a maxillary antrostomy.<sup>2</sup> They found an agreement rate of greater than 85%. However, comparisons between the swab and suction traps have not been carried out to the same extent.

SCN, *S. aureus*, and diphtheroids are potential pathogens that frequently colonize healthy noses.

Healthy flora from the middle meatus using endoscopic visualization has been investigated previously using the swab method. Nadel and colleagues demonstrated SCN (36%), *S. aureus* (20%), and diphtheroids (16%) as being the most prevalent aerobes harvested from the middle meati of 25 normal subjects.<sup>8</sup> Another study by Klossek and colleagues demonstrated SCN (50%), corynebacteria (20%), and *S. aureus* (12.6%) to be the most prevalent isolates cultured from the middle meati using nasal swabs in 139 samples from healthy subjects.<sup>9</sup> These results confirm the presence of an aerobic flora in the healthy adult middle meatus consisting of SCN, *S. aureus*, diphtheroids, and corynebacteria. In our study, SCN, *S. aureus*, and diphtheroids were among the most prevalent bacteria obtained from both the wire swab and the suction traps. A common concern with bacterial culture isolation techniques is the recovery of normal nasal flora leading to a potential false-positive diagnosis of rhinosinusitis. In addition to positive cultures, other tools, such as clinical and endoscopic pictures, are increasingly being used to confirm the diagnosis of sinusitis.

The role of SCN as a true pathogen remains controversial in patients with chronic bacterial rhinosinusitis. Using nasal endoscopy, Bolger isolated SCN in 17% of cultures and Hsu and colleagues in 42% of cultures,<sup>3,13</sup> and Nadel and colleagues retrieved SCN from 35% of cultures in patients with chronic sinusitis and 36% in the control group.<sup>6,8</sup> They felt that heavier growth of SCN should suggest true infection, whereas light growth probably represents contamination. Using the nasal swab, we found a high incidence of light or moderate growth of SCN and a low incidence of heavy growth of SCN. Our results appear to support SCN as a commensal flora in the majority of isolates. We agree that only a heavy (3+) growth of SCN should be considered pathogenic regardless of the culture method used.

Our results suggest a slight decrease in the isolation of commensal SCN flora using the suction trap compared with the wire swab. The agreement between the two isolation techniques was relatively low ( $\kappa = 0.45$ ). This lack of agreement may be due to contamination of the wire swab by the nasal vibrissae or nasal wall. It is possible that no matter how careful the endoscopist is, it may be almost impossible to enter and exit the nose without some risk of contamination of the wire swab by the nasal vibrissae or nasal walls.

Nadel and colleagues felt that the quantification of *S. aureus* on culture gave a great deal of information on whether the organism was saprophytic or pathogenic.<sup>3</sup>

We isolated *S. aureus* at a frequency similar to that of previously published studies.<sup>3,6,7,13</sup> Using the wire swab, *S. aureus* was cultured from 15.4% of patients. The agreement between *S. aureus* captured by the wire swab and the suction trap as measured by concordance was relatively high ( $\kappa = 0.72$ ), indicating that both bacterial isolation methods consistently captured *S. aureus* from the same site. Nadel and colleagues suggested that light growth of *S. aureus* was a probable indication that the organism was a saprophyte. They observed that *S. aureus* isolated from the control group was always light growth and *S. aureus* isolated from chronic rhinosinusitis patients was usually heavy growth. Unfortunately, the lack of healthy controls in this study precludes us from definitively supporting their findings. However, the relative paucity of light growth obtained by either culture method in patients with clinical evidence of disease suggests that heavy growth, and possibly moderate growth, is indicative of a true pathogen.

Gram-negative enteric bacteria particularly from the Pseudomonadaceae and Enterobacteriaceae families have become increasingly suspicious as true pathogens in nonimmunocompromised chronic sinusitis patients. In a group of patients similar to ours, Bolger isolated gram-negative enteric bacteria from 47 of 138 cultures (34.1%).<sup>3</sup> Using the wire swab, we found a gram-negative culture rate of 30.8% (16 of 52 cultures). The XSSC isolated gram-negative bacteria at a rate of 52% (13 of 25 cultures) and the Leukens trap at a rate of 48.1% (13 of 27 cultures). The concordance between gram-negative enteric bacteria isolated by the wire swab and the suction traps was relatively high ( $\kappa = 0.72$ ). There is little doubt that gram-negative bacteria play a significant role in chronic bacterial rhinosinusitis. A rabbit study by Bolger and colleagues showed that sinusitis induced by *P. aeruginosa* caused an intense transmucosal injury. This could explain the recalcitrant nature of clinical gram-negative sinusitis observed in these patients.<sup>14</sup>

Conventional antibiotic therapy for sinusitis has been guided by culture results. Given that more than one culturing method exists, it is important that the most effective method be used when obtaining culture results. A study by Tantilipikorn and colleagues demonstrated that, despite the theoretical advantage that suction devices are felt to exhibit, no statistical advantage can be seen when compared with swab methods.<sup>15</sup> With regard to both contamination rate and number of isolates, Tantilipikorn and colleagues' study demonstrated little difference between both devices. Our study

is in accordance with these findings, with an agreement rate of 76.9% between the suction traps and the wire swab.

It is important to use both the most clinically and cost-efficient method available in identifying pathogenic organism(s) to allow appropriate culture-directed treatment to be instituted. On a per patient basis, the XSSC suction trap costs an average of \$20 each, the Leukens suction traps \$1.74 each, and the wire swab \$0.5 each. In an attempt to reduce clinical costs, the lower-cost but efficacious wire swab may be the more advantageous tool. Another advantage of the wire swab is that it can be placed in cultured medium immediately compared with the suction trap contents, which can dry en route to the laboratory.

Although the aim of this study is not to determine the role that specific bacteria contribute in the pathogenesis of chronic sinusitis, it does provide some additional information. This study serves to demonstrate a direct comparison of cultures obtained via two different methods (swab vs suction devices). In understanding the culturing capacity of different methods, we found that sinus surgeons may not have any real advantage using one method over another to obtain cultures.

## Conclusion

The findings of this study suggest that the wire swab appears to be as efficacious at obtaining endoscopically guided cultures as the Xomed and Leukens suction devices.

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