

Radiographic imaging studies in pediatric chronic sinusitis

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Background: The diagnosis of chronic sinusitis is dependent on the radiographic evidence of sinus disease.

Methods: We evaluated the performance of radiographs and computed tomographic (CT) scans for the examination of the paranasal sinuses of 91 patients of both sexes, ranging in age from 2 to 17 years, who had chronic upper respiratory tract symptoms for at least 3 months. The CT scan findings were categorized as no disease; minimal disease, and mild, moderate, and severe sinusitis.

Results: Fifty-eight patients (63%) had chronic sinusitis: CT scan abnormalities were minimal in 17%, mild in 19%, moderate in 21%, and severe in 43%. There was a statistically significant correlation between rhinorrhea ($r = 0.25$, $p = 0.01$), cough ($r = 0.27$, $p = 0.009$), and the severity of sinus abnormality as determined by CT scan. Clinical presentation in the mild, moderate, and severe sinusitis groups ($p < 0.05$) was significantly different from that of the no disease group, whereas the minimal disease group had subclinical presentation ($p = 0.11$). Clinically significant chronic sinusitis often occurred at multiple sites: 44% of patients had pansinusitis, 50% had disease involvement of at least two sinuses, and 6% had disease in a single sinus. When sinus radiographs were compared with CT scans ($n = 70$ cases), radiographs could not identify minimal disease. For clinically significant sinusitis, sinus radiographs detected disease in 1 of 5 (20%) frontal sinuses, 0 of 12 (0%) sphenoidal sinuses, and 17 of 31 (54%) ethmoidal sinuses. With the minimal criteria of 40% to 50% opacification or fluid level filling of the maxillary antrum, radiographs detected disease in 37 of 49 (75%) cases. The sensitivity and specificity for a Waters view to confirm clinically significant chronic sinusitis without specifying the sites and severity were acceptable at 76% and 81%, respectively. When limited sinus CT scans were compared with full CT evaluation ($n = 49$ cases), limited studies detected 5 of 5 (100%) frontal, 9 of 11 (82%) sphenoidal, 14 of 19 (73%) ethmoidal, and 39 of 40 (97%) cases of maxillary sinusitis. The overall agreement was 88%.

Conclusions: A single Waters view is an acceptable part of the initial evaluation of pediatric chronic sinusitis; however, a limited CT scan is a better alternative. (*J ALLERGY CLIN IMMUNOL* 1994;94:523-30.)

Key words: Sinus CT scans, pediatric chronic sinusitis, sinus radiographs, limited sinus CT scans

Advances in diagnostic imaging techniques have challenged traditional concepts of pathogenesis, diagnosis, and treatment of sinus disease in children and adults.^{1, 2} Because chronic sinusitis in

Abbreviation used

CT: Computed tomographic

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children has clinical features similar to those of other common chronic respiratory diseases,^{3, 4} imaging assessment of paranasal sinuses is an important issue, not only for diagnosis but also for subsequent appropriate medical management.^{5, 6} Although numerous diagnostic aids are available, most are inadequate. Ultrasonography is less efficient than the sinus radiograph and only detects maxillary sinus cavity fluid.^{7, 8} Transillumination is difficult to perform and is only useful in older

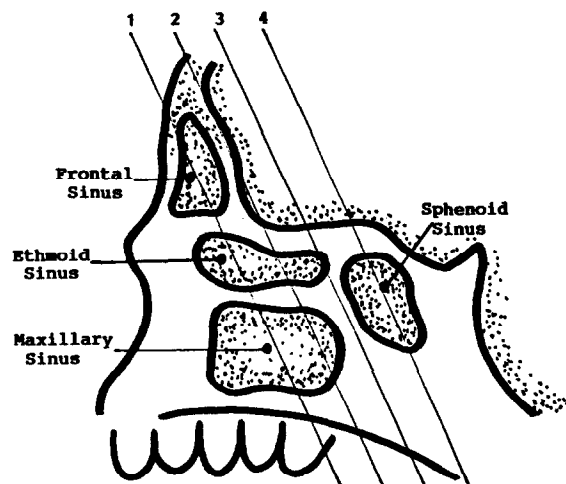


FIG. 1. Diagram of the lateral view of the paranasal sinuses. The lines show the location of the coronal imaging cuts for limited sinus CT scan examination.

children and in cases of severe sinus disease.⁸ Nasal endoscopy requires skills and experience, not only to pass the scope but to differentiate normal variations from abnormal lesions.⁹ Furthermore, endoscopy is difficult to perform in children, and sedation or general anesthesia may be required.⁹ The two widely available diagnostic imaging techniques are the sinus radiograph and the computed tomographic (CT) scan. Although the sinus radiograph is safe and rather economical, its accuracy has been questioned because it has a high rate of false-negative, as well as false-positive results.^{10, 11} Stricter criteria for abnormal sinus radiograph have recently been proposed¹²; however, no data are currently available to evaluate the accuracy of these new criteria. The CT scan provides excellent images of the sinuses, but it has two drawbacks: radiation and cost. The limited sinus CT scan may prove to be a viable option, with both reduction in radiation and increased cost-effectiveness.

In this study we classified the degree of severity of abnormal sinus CT scan results and examined the correlation with the clinical symptoms of pediatric chronic sinusitis. We then evaluated the performance of the sinus radiograph and the limited sinus CT scan compared with the full standard sinus CT scan. Lastly, we compared the cost and radiation exposure of these imaging studies.

METHODS

The methods used in this study have been described in details elsewhere.¹³ Only the key features are mentioned here.

Patients

All new patients, of both sexes and ranging in age from 2 to 18 years who had upper respiratory tract symptoms for at least 3 months, were eligible to enter the study. Gross facial deformity, immunodeficiency, or cystic fibrosis were exclusion criteria. Eligible patients had allergy skin tests, sinus radiographs, CT scan of the paranasal sinuses, complete history, and physical examination.

Rhinitis and sinusitis symptom scores

The severity of clinical symptoms of rhinorrhea/sneezing, nasal congestion, sneezing, postnasal drip, headache, coughing, and wheezing were scored from 0 to 3 (0 = absent, 1 = mild, 2 = moderate, and 3 = severe) as determined by criteria published previously.¹⁴ The criteria for rhinorrhea/sneezing were 0: none; 1: sneezing or tissues needed 1 to 4 times daily; 2: sneezing or tissues needed 5 to 10 times daily; and 3: nose runs freely despite frequent use of handkerchief or tissues. The criteria for cough were 0: none; 1: occasional cough, not uncomfortable, no interference with school or sleep; 2: frequent cough, annoying but not distressing, 2 to 3 days a week; 3: cough almost every day and night, distressing spells, possibly interfering with sleep or school work.

The total clinical symptom scores were calculated by adding the scores of rhinorrhea and cough, then categorized as follows: minimal symptoms (scores from 0 to 2), mild symptoms (scores from 3 to 4), and moderate to severe symptoms (scores from 5 to 6).

Radiograph and CT scan of the paranasal sinuses

All x-ray films were read by radiologists who were blinded to the clinical information.

Sinus radiographs consisted of occipitofrontal (Caldwell), lateral and occipitomental (Waters) views. The minimal criteria for an abnormal maxillary sinus was thickened mucosa, opacification, or air fluid level filling at least 40% to 50% of the antrum (one-dimensional) observed in the Waters radiograph.¹² The criteria for abnormal ethmoidal, sphenoidal, and frontal sinuses were mucosal thickening, opacification, or air fluid level at any degree of severity observed in the Caldwell view for ethmoidal, the lateral view for sphenoidal, and the Waters view for frontal sinuses. Each sinus radiograph was read independently by two pediatric radiologists to prevent personal bias.

Sinus CT scans consisted of coronal views with bony and soft tissue windows at 4 mm increments and without contrast enhancement. Any abnormality had to be seen in both soft tissue and bony window images to prevent false-positive and false-negative readings.¹⁵ The severity of sinus abnormality was estimated and scored for frontal, ethmoidal, sphenoidal, left and right maxillary sinuses as follows 0: no abnormality, 1: mucosal thickening less than 20% to 25% of the diseased sinus's volume (three-dimensional), 2: mucosal thickening, air

TABLE 1. Distribution of the symptom complex (rhinorrhea and cough) associated with the severity of sinus CT scan abnormalities

Sinus CT scan findings	Severe (n = 25)	Moderate (n = 12)	Mild (n = 12)	Minimum (n = 10)	Normal (n = 32)
Moderate to severe symptoms (scores: 5 to 6)	64%	33%	67%	40%	22%
Mild symptoms (scores: 3 to 4)	28%	50%	33%	60%	50%
Minimal symptoms (scores: 0 to 2)	8%	17%	0%	0%	28%

The table shows the percent of patients with severe, moderate, mild, or minimal symptoms associated with sinus CT scan abnormality. There were significant statistical differences for the clinical symptom scores between normal and mild, normal and moderate, and normal and severe sinus CT scan abnormality groups ($p < 0.05$). No statistical difference existed between normal and minimal disease groups ($p = 0.11$).

fluid, or opacification from 20% to 40% involvement, 3: mucosal thickening, air fluid, or opacification from 40% to 80% involvement, 4: disease involvement from 80% to total opacification.

The index of overall severity of the sinus CT scan was computed by adding the score of each diseased sinus group. The severity was categorized as follows:

- Category 0: Total score = 0; no disease in any sinus
- Category 1 (minimal): Total score = 1 less than 20% to 25% mucosal thickening, air fluid level or opacification in only one sinus group
- Category 2 (mild): Total score = 2 to 5 ranging from at least 20% to 25% disease involvement in one sinus group to complete opacification of one sinus group and 20% to 25% mucosal thickening in a second sinus group. Most patients in this category had disease in 2 sinus groups at 20%-25% to 40% involvement.
- Category 3 (moderate): Total score = 6 to 9; most patients in this category had 40% to 80% disease involvement of two to three sinus groups.
- Category 4 (severe): Total score > 9; pansinusitis or disease involvement of at least three sinus groups with almost or total opacification. Most patients in this category had pansinusitis.

The limited sinus CT scan consisted of four preselected slices from the full coronal CT scan. Two slices were chosen at the estimated midpoint of frontal and sphenoidal sinuses. Two more slices, which cut through the ethmoidal and maxillary sinuses, were selected at equal intervals between the midpoint frontal and sphenoidal sinus slices (Fig. 1). Both soft tissue and bony window images were selected. For each category (from 0 [no disease] to 4 [severe disease]), 10 randomly limited sinus CT scans were reviewed (total 49 limited studies). All films were read in blinded fashion and random order by a single radiologist. The interval from the first review of the full sinus CT scan to the review of the limited CT scan was about 6 months. The preselected slices of sinuses were evaluated as follows: (1) not imaged, (2) not developed, (3) accurate evaluation not possible, (4) no disease, and (5) severity of

disease as of category 1 to 4 (same above criteria as full sinus CT scan).

The results of the sinus radiograph and limited sinus CT scans were compared with result of full sinus CT scans. The full CT scan was considered the gold standard.

Definition of chronic sinusitis

Chronic sinusitis was defined, according to the criteria proposed by Shapiro and Rachelefsky,¹² by the presence of two of three major clinical signs (rhinorrhea, postnasal drip, and cough) for at least 3 months and confirmed by a Waters radiograph with opacification, air fluid level, or thickened mucosa filling at least 50% of maxillary antrum and/or coronal sinus CT scan with mucosal thickening, air fluid level, or opacification of sinus.¹²

Statistical analysis

Data were reported as means $\pm$ SEM, unless otherwise indicated. The data were analyzed by construction of 2×2 tables, chi square analysis, Pearson's correlation coefficient, and multiple regression analysis. The calculation was performed with the Stat2 software program (Statsoft Inc., Tulsa, Okla.) on a personal computer.

RESULTS

Ninety-one patients who had upper respiratory tract symptoms for at least 3 months were entered in the study. Full sinus CT scan results were abnormal in 58 (63%) patients. All patients who had abnormal CT scan results had clinical symptoms that fit the criteria of chronic sinusitis as defined by Shapiro and Rachelefsky.¹² Of the patients who had chronic sinusitis, 17% (10 of 58) had minimal, 19% (11 of 58) had mild, 21% (12 of 58) had moderate, and 43% (25 of 58) had severe sinus CT scan abnormalities. All of the patients in the minimal category had minimal (< 20% to 25% mucosal thickening) CT scan abnormalities confined to a single sinus. In patients who had more

TABLE II. Correlation coefficients of frontal, sphenoidal, maxillary, and ethmoidal sinusitis

Disease in each sinus was correlated to	Correlation coefficient (<i>r</i>)	<i>p</i> Value
Frontal sinus		
Sphenoiditis	0.33	0.001
Maxillary sinusitis	0.27	0.007
Ethmoiditis	0.39*	0.0003
Sphenoidal sinus		
Frontal sinusitis	0.33	0.001
Maxillary sinusitis	0.53	<0.00001
Ethmoiditis	0.60*	<0.00001
Maxillary sinus		
Frontal sinusitis	0.27	0.007
Maxillary sinusitis	0.53	<0.00001
Ethmoiditis	0.69*	<0.00001

*Although chronic sinusitis in pediatric patients tends to occur at multiple sites, ethmoiditis has the greatest correlation value with frontal, sphenoidal, and maxillary sinusitis.

severe disease, sinus abnormalities often occurred at multiple sites: 21 of 48 (44%) patients had pansinusitis, 14 (29%) had disease involvement of three sinuses, 10 (21%) had disease involvement of two sinuses, and only three (6%) had significant disease in a single sinus. Among all of the clinical symptoms that we examined only rhinorrhea ($r = 0.25$, $p = 0.01$) and cough ($r = 0.27$, $p = 0.009$) were significantly correlated with the severity of sinus disease identified by CT scans. Because Kennedy¹⁶ reported that minor mucosal changes observed on CT scans had no clinical significance, we examined the correlation between the severity of these clinical symptoms and the severity of CT scan abnormalities by grouping all studied patients according to the clinical scores. Table I shows the distribution of clinical presentation associated with the severity of CT scan findings. There was no statistical difference ($\chi^2 = 5.9$, $p = 0.11$) in the clinical presentation between normal and minimal disease groups. In contrast, clinical features significantly differed between the normal and mild ($\chi^2 = 10.0$, $p = 0.01$), normal and moderate ($\chi^2 = 9.8$, $p = 0.007$), normal and severe ($\chi^2 = 64.2$, $p = 0.001$) sinus CT scan abnormalities. Therefore the data suggested that chronic sinusitis with minimal sinus CT scan abnormalities was not clinically significant at the time of evaluation.

Among 48 patients who had clinically significant chronic sinusitis (CT scan abnormalities in the mild, moderate, or severe category), 81% demonstrated ethmoidal, 71% demonstrated maxillary, and 44% demonstrated sphenoidal disease. Frontal sinusitis occurred in only 12.5% of patients. Maxillary sinusitis tended to occur bilaterally (76%). Because chronic sinusitis was often

present at multiple sites, the significant correlations among frontal, ethmoidal, sphenoidal, and maxillary sinusitis were no surprise (Table II). However, ethmoiditis still had the greatest association with disease in frontal, sphenoidal, and maxillary sinuses (Table II). We also observed that mild ethmoiditis progressed to a more severe chronic sinusitis in several noncompliant patients. Fig. 2 shows progressive disease from 25% opacification of the ethmoidal sinuses to complete ethmoidal opacification, spreading to bilateral maxillary sinuses within a 2-month period. Therefore the data suggest that ethmoiditis may have a pivotal role in the pathogenesis of sinusitis in the dependent sinuses.

Of 91 patients studied, only 70 were evaluated by both sinus radiographs and CT scans because of parental refusals or accidental omission. Sinus x-ray films were read independently by two pediatric radiologists. Their rate of agreement was 98%, 82%, 94%, and 94% for frontal, ethmoidal, sphenoidal, and maxillary sinuses, respectively. Sinus radiographs could not detect any case of sinus disease at the minimal degree of severity. Because our data also suggested that minimal chronic sinusitis was not clinically significant at the time of evaluation, abnormal sinus radiographs were only compared with CT scans that showed mild, moderate, and severe degrees of sinusitis. There were 39 (55%) patients who had significant chronic sinusitis confirmed by sinus CT scans. Compared with CT scan findings, sinus radiographs detected diseases in 1 of 5 (20%) frontal and 0 of 12 (0%) sphenoidal sinuses. There were no false-positive cases. For ethmoiditis, radiographs were positive in 17 of 31 (54%) cases with 7 false-positive and 14 false-negative

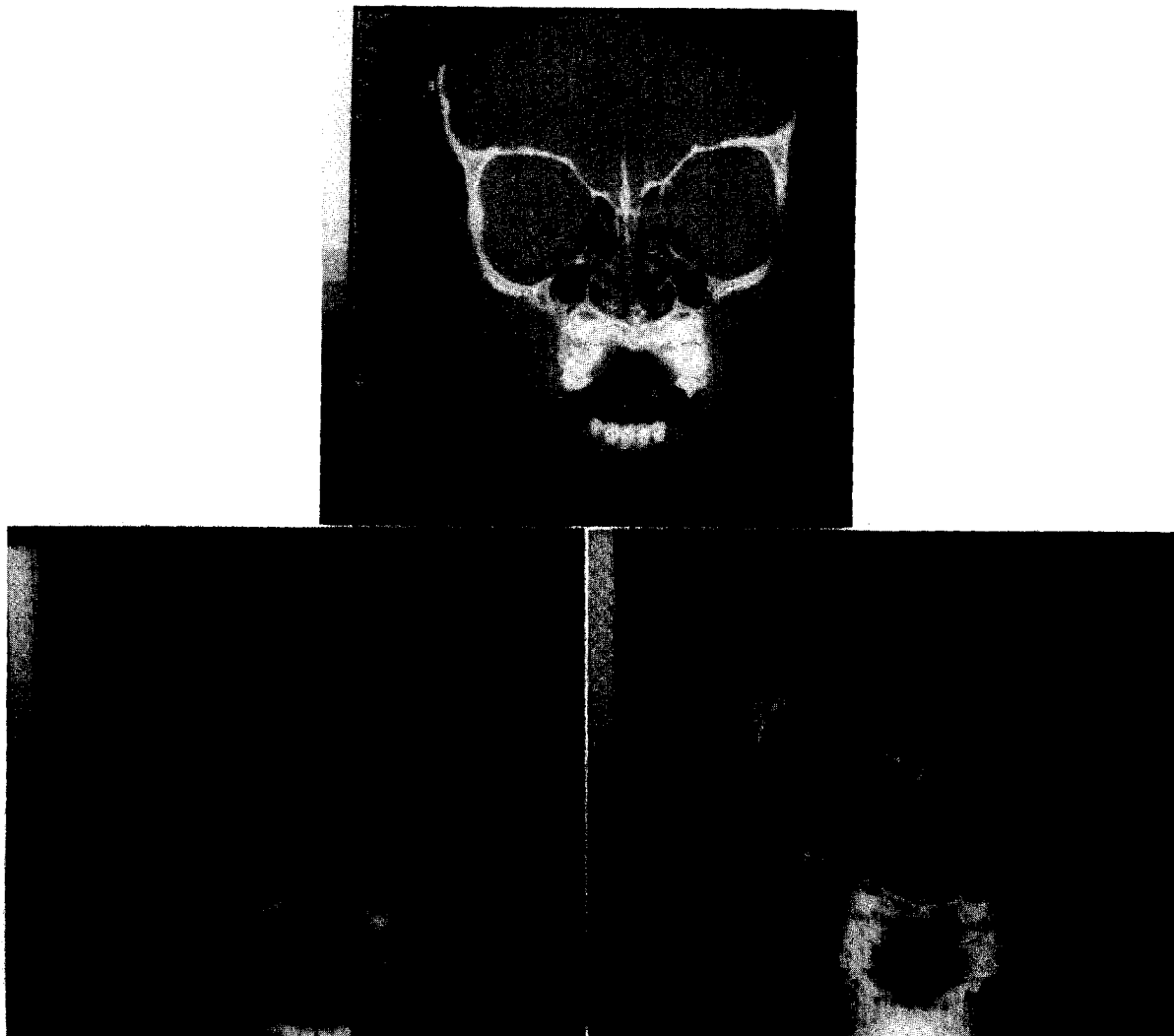


FIG. 2. Progressive chronic sinusitis in a noncompliant patient. **A**, Coronal CT scan at the initial evaluation showed only mucoperiosteal thickening of the ethmoidal sinuses. **B**, Within 5 weeks, ethmoiditis was worsening and spreading to maxillary sinuses. **C**, CT scan showing complete opacification of ethmoidal sinuses, almost complete opacification of right maxillary sinus, and 30% mucoperiosteal thickening of left maxillary sinus after another 4 weeks.

results. With the use of the criteria proposed by Shapiro and Rachelefski¹² for abnormal maxillary sinus at 40% to 50% of mucosal thickening or opacification, sinus radiographs detected maxillary disease in 37 of 49 (75%) cases with three false-positive and 12 false-negative results (Table III).

Although the data clearly show that sinus radiographs cannot indicate the extent and location of sinus disease accurately, the perspective of allergists is much different from that of our surgical colleagues. We simply need to confirm the clinical suspicion in order to initiate noninvasive medical management. Therefore we ask how well the sinus radiograph performs in identifying or refuting whether a given patient has or

does not have sinus disease—a simple yes or no question.

Among 70 patients who had both sinus radiographs and CT scans, 39 (55%) had significant chronic sinusitis and 31 (45%) had minimal or no disease. Because the presentation of minimal disease in our study was subclinical, patients with minimal disease were considered as having no disease for this purpose. With its best performance in evaluating maxillary disease with the criteria proposed by Shapiro and Rachelefsky,¹² Waters view radiographs were considered to be abnormal if the criteria were met in one of two maxillary sinuses. Sinus radiographs confirmed the presence of significant chronic sinusitis in 30 cases with nine false-negative and six false-posi-

TABLE III. Comparison of findings of sinus radiographs, limited sinus CT scans, and to full sinus CT scans

Examination	Sinus radiographs	Limited CT scans
Sinuses		
Frontal	20%	100%
Ethmoidal	54%	73%
Sphenoidal	0%	82%
Maxillary	75%	97%

With full sinus CT scan as the gold standard, the table shows the percentage of disease detected by either sinus radiographs or limited CT scans for frontal, ethmoidal, sphenoidal, and maxillary sinuses.

tive results. The sensitivity was 76%, and the specificity was 81%.

Forty-nine limited CT scan studies were randomly chosen from all five categories of severity of chronic sinusitis for evaluation. Compared with full CT scans, limited studies detected diseases in 5 of 5 (100%) frontal sinuses and 9 of 11 (82%) sphenoidal sinuses with two false-negative results and one false-positive result. In 19 cases of ethmoiditis, results of limited studies were abnormal in 14 (73%), with 5 false-negative and 0 false-positive results. Limited studies detected disease in 39 of 40 (97%) maxillary sinuses with one false positive result and one false-negative result (Table III). There were only three cases of frontal sinuses in which the judgment was "accurate evaluation not possible." In no instance did a limited study fail to image an individual sinus. In general, a limited study was less reliable in identifying minimal or isolated disease. Limited studies tended to underestimate rather than overestimate the severity of sinus disease. The overall agreement rate between limited and full CT scans was 88%.

DISCUSSION

Computed tomography has contributed greatly to clinical medicine as an advance in diagnostic imaging methods since its introduction in 1974. Since then, it has become the "gold standard" for delineating sinus and nasal anatomy and disease.¹⁷ However, it is not without controversy. Several studies have examined the incidental sinus abnormalities on cranial CT scans in pediatric patients,^{18, 19} but they usually failed to correlate the "abnormal" findings with the recent or recurrent clinical symptoms of respiratory infection or to classify the degree of abnormality of the radiographic findings. These studies also favored high false-positive readings either by using thicker and lower resolution images¹⁸ or by routinely examining soft tissue images.¹⁹ In our study all patients

who had chronic sinusitis met the clinical and radiographic criteria for sinusitis proposed by Shapiro and Rachelefsky.¹² We also classified the degree of severity of the sinus CT scan findings with the clinical symptoms. Our data suggested that patients who had minimal mucosal thickening in an isolated sinus detected by CT scans probably did not have clinically significant chronic sinusitis at that particular time because their clinical presentations were not different from patients who had allergic or nonallergic rhinitis and normal CT scans. Of 91 patients in our study, 10 (11%) patients had minimal disease. Our results are in accordance with the report by Glasier et al.¹⁹ in which 18% of pediatric patients (older than 1 year) who showed sinus abnormality on cranial CT scans without correlated clinical symptoms, even though the study's design tended to favor false-positive readings. Our findings are also in agreement with the report by Kennedy¹⁶ that minor mucosal changes on CT scans may have no relation to the clinical symptoms, particularly if they are not causing osteomeatal complex obstruction.¹⁶

With the dramatic advance in imaging provided by the CT scan and the availability of diagnostic nasal endoscopy, it has been suggested that chronic sinusitis is primarily a disease of obstruction, especially the osteomeatal complex in the ethmoidal sinuses, which leads to a subsequently secondary inflammation in the dependent sinuses.²⁰ In our study the data show that the ethmoidal sinus is the the most frequent site of inflammation. The data also suggest that disease in the ethmoidal sinuses would lead to disease in the dependent sinuses such as the maxillary, frontal, and sphenoidal sinuses (Fig. 2). However, the obstruction of the osteomeatal complex, which is located within the ethmoidal sinuses, generally may not be due to structural abnormalities or variants but to mucosal inflammation^{21, 22}; because Bolger et al.²³ have reported that the prevalence

of sinus anatomic variations (such as pneumatization of the middle turbinate, Haller's cells, paradoxical curvature of the middle turbinate, and pneumatization of the uncinate process) are similar in patients with and those without clinical symptoms of chronic sinusitis in a study of 202 sinus CT scans.

The radiograph has been the mainstay for the examination of the paranasal sinuses for many years; however, there is disagreement over the interpretation and reliability of the sinus radiograph in pediatric patients.^{24, 25} In fact, there are no definite criteria with which to identify disease in the ethmoidal or sphenoidal sinuses except for "clouding" or opacification.^{24, 25} The criteria for maxillary sinusitis have varied from 3 mm to 4, 5, and 6 mm mucosal thickening.²⁶⁻²⁸ Comparative study of sinus radiographs and CT scans of pediatric patients with chronic sinusitis showed a 75% rate of discrepancy with a 45% false-positive rate and 35% false-negative rate for sinus radiographs.¹⁰ In our study sinus radiographs were not able to identify minimal sinus disease with subclinical presentation. At the other degree of severity, they were also unreliable in diagnosing sphenoiditis and often missed significant disease in frontal and ethmoidal sinuses. Our results are in agreement with those of other studies.^{10, 11, 29} Shapiro and Rachelefsky¹² recently proposed, as stricter diagnostic criteria for maxillary sinusitis, mucosal thickening, air fluid level, or opacification filling at least 50% of the antrum. With the use of these most recently proposed criteria, sinus radiographs were more accurate in identifying 75% of significant maxillary disease as compared with CT scans. Because maxillary sinusitis is the second most common site of disease (after ethmoiditis), the Waters view sinus radiograph may identify the presence or clinically significant sinusitis, although not the extent and location of the disease, in most patients. Its sensitivity and specificity were reasonably acceptable at 76% and 81%, respectively. However, negative Waters view does not exclude sinus disease because our data also show that 24% of cases of significant sinus disease had been missed.

Limited sinus CT scan examinations were first proposed and practiced by White et al.³⁰ in 1989, with the purpose of reducing cost and radiation exposure. Limited CT scan studies usually consist of 4 slices, which are designed to produce at least one image of frontal, ethmoidal, sphenoidal, and maxillary sinuses. Gross et al.³¹ in a study of 10 limited sinus CT scans in children, which were read by four radiologists, found a 79% rate of

agreement with results of full CT studies. Although the overall agreement was lower than expected, the authors suggested that the discrepancy may be correlated with interobserver variability of a very small number of cases. In our study a total of 49 studies, which comprised all categories of chronic sinusitis, were read by a single radiologist. The overall rate of agreement with results of the full sinus CT scan was 88%. In general, the disadvantages of CT scan are: radiation exposure, cost, sedation, and scheduling time. Because the limited sinus CT scan has only 4 slices, instead of 16 to 20 slices as in the full CT scan, radiation exposure is reduced by at least three to four times. The radiation exposure may be significantly reduced further with the use of lower milliamperage second settings without compromising diagnostic quality.^{32, 33} The use of limited numbers of slices and lower milliamperage second settings may translate into a faster study, better toleration by patients, and more efficient use of the CT suite. These changes would also reduce the cost further in the future. Although orally administered chloral hydrate is safe and effective for sedation of pediatric patients for diagnostic imaging studies,^{34, 35} a limited sinus CT scan with a faster study time would further reduce the need for sedation. The limited CT scan, however, is not a comprehensive examination of the paranasal sinuses.

Compared with the sinus radiograph, the limited sinus CT scan has significantly higher radiation exposure and cost. In a survey of 250 CT systems, McCrohan et al.³⁶ reported that the average radiation dose for each head CT scan image ranges from 2.2 to 6.8 rad. At our institution the average radiation dose for each cut of sinus CT scan is 2.6 rad (GE 9800 scanner [GE Medical Systems, Waukesha, Wis.], 120 kilovolt [peak], 80 mA-2.5 sec) whereas one view of a sinus radiograph averages about 0.6 rad. The current cost of a limited CT scan at our institution is about half the cost of a full CT scan and twice the cost of a 3-view sinus radiograph. Therefore the sinus radiograph is still the most cost-effective and safest imaging study for initial examination of the paranasal sinuses. Perhaps only a single Waters view is needed. For the estimated 25% of patients who have significant chronic sinusitis and negative sinus radiograph results, the use of limited sinus CT scan (if available), empirical treatment, or full sinus CT scan is at the discretion of the attending physicians.

In conclusion, we compared the performance of the routine sinus radiograph and the limited sinus

CT scan with the full sinus CT scan and found that the radiograph has an acceptable sensitivity and specificity as part of an initial evaluation for pediatric patients with chronic upper respiratory tract symptoms, although it cannot accurately show extent and site of sinus disease. A limited sinus CT scan has much better performance than a sinus radiograph and is more cost-effective than a full CT scan, especially for physicians who are not surgeons. Low-dose limited sinus CT scan may be the procedure of choice for the examination of the paranasal sinuses in the near future, as radiation exposure and cost become comparable with those of routine sinus radiographs.

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