Comparison of Plain Radiographs and Coronal CT Scans in Infants and Children with Recurrent Sinusitis

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We performed a prospective study of 70 infants and children with recurrent sinusitis. We compared plain radiographs with coronal CT scans of the sinuses to determine if plain radiographs can be used to accurately diagnose and localize residual sinus disease amenable to endoscopic surgery. This residual disease is thought to be important in the pathogenesis of recurrences of sinusitis. The patients were taking antibiotics and were clinically well at the time of the two examinations (performed on the same day). Findings on slightly over 80% of the CT scans were abnormal. In about 75% of the patients, the findings on plain radiographs did not correlate with those on CT scans. About 45% of the patients had normal findings on plain radiographs of at least one sinus with an abnormality of that sinus shown on CT scans. Almost 35% of the patients had what was interpreted as an abnormality of at least one sinus on plain radiographs, but that sinus was normal on CT scans.

Sinusitis in infants and children is often underdiagnosed or overdiagnosed on the basis of findings on plain radiographs of the sinuses. Plain radiographs cannot be used to determine the need for, or to guide, endoscopic surgery on the sinuses.


Recurrent chronic sinusitis is a common clinical problem in pediatric patients. Some investigators believe that the anterior ethmoid-middle meatal complex (osteomeatal complex) is important in the pathogenesis of recurrences of sinusitis [1]. Residual inflammatory changes in the anterior ethmoid sinuses can infect the drainage area in the middle meatus or the common area where the maxillary and frontal sinuses also drain. It is unclear how accurate paranasal sinus radiographs are for detecting sinus disease in the pediatric population. We undertook a prospective study of infants and children with a clinical history of recurrent chronic sinusitis to compare conventional radiographs with coronal CT scans of the paranasal sinuses and to determine if radiographs are sufficiently diagnostic to guide endoscopic surgery of the sinuses.

Subjects and Methods

Seventy children, ranging in age from 4 months to 19 years (Table 1), who fulfilled the criteria for recurrent chronic sinusitis were selected. Each had a history of purulent nasal discharge, fever, frequent cough, and plain radiographic evidence of opacification of one or more sinuses. The patients had been treated with appropriate antibiotics, nasal decongestants, and nasal steroids, but had recurrences of symptoms when antibiotic therapy was discontinued. At least one infection was documented with plain radiographs. All patients had been clinically free of disease for more than 2 weeks, and most had been taking antibiotics for 4 weeks at the time of the radiographic and CT examinations. The study was approved by the human studies committee. All patients in the study had conventional sinus radiographs consisting of Caldwell, Waters, and lateral projections. The Waters projections in infants and young children were at lesser angulation. Patients who could cooperate, mainly those 6 years old or older, received a submentovertex projection. The coronal CT scans were performed...
on the Siemens Somatom DRH and were 4-mm-thick slices with 3-
mm increments. The gantry angulation varied depending on cranial hyperextension. The kilovoltage setting was 125, and the scanning
time was 3–4 sec. The window width was 2000, with a center of 0.
The images were zoomed to fill the screen. No nasal decongestants
were used before scanning. Infants and younger children were se-
dated with IV nembutal and were monitored by a nurse using a pulse
oximeter. Sagittal reconstructions through the ethmoidal sinuses
were performed with magnification that made the scans anatomically
correct in size. This permitted direct measurements on the scan from
the inferior anterior nasal spine to the cribiform plate or sphenoidal
sinus, which could be used to judge the depth of the sinus during
endoscopic surgery.

The plain radiographs were interpreted prospectively by three
pediatric radiologists and the coronal CT scans, by three neurora-
diologists. The CT scans were interpreted independently of the plain
radiographs. The ethmoidal air cells were divided into anterior, middle,
and posterior, although the middle cells are part of the anterior
system. The amount of mucous membrane thickening, opacification,
air-fluid levels, location of disease, and bone destruction were re-
corded. The appearance of the mucosa in the nasal cavity was
assessed. Interpretations of the sinus radiographs and CT scans
were compared, and any discrepancies noted. Any disagreements in
interpretations of both the sinus radiographs and coronal CT scans
were recorded and reviewed retrospectively. The floppy disks were
saved, and the CT scans were reviewed with manipulation of the
window widths in discrepant cases. The CT scans were considered
the gold standard—that is, in the case of discrepancies the CT scan
was considered to be the correct answer. Each maxillary sinus and
each ethmoidal sinus was evaluated separately (140 sinuses). The
sphenoidal sinuses were considered to be one sinus, as were the
frontal sinuses. Fifty-eight sphenoidal and 32 frontal sinuses were
evaluated.

Results

Of the 70 patients studied (ages listed in Table 1), 57 (81%)
had an abnormality of a sinus shown on coronal CT scans. In
52 (74%) of the 70 patients, discrepancies were seen between
the interpretations of plain radiographs and those of CT scans.
Thirty-two patients (46%) had normal plain radiographic find-
ings of a sinus but had abnormal findings on CT of that sinus.
The findings are summarized in Table 2. There were more
discordant interpretations of the ethmoidal sinuses than of
any other sinuses. The abnormalities noted only on CT in-
cluded partial ethmoidal clouding, small sphenoidal or frontal
sinuses with soft-tissue disease, and posterior or medially
placed mucous membrane thickening or retention cysts of
the maxillary sinuses. Some maxillary sinuses that appeared
opacified on plain radiographs were shown to be retention
cysts on coronal CT scans (Fig. 1).

<table>
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Fig. 1. A, Waters projection radiograph of a 9-year-old interpreted as complete opacification of maxillary sinus.
B, Coronal CT scan shows a large retention cyst.
The number of patients with abnormal findings on plain radiographs of a sinus but normal findings on CT scans of that sinus (Fig. 2) was 24 (34%) of 70 patients. Errors in plain films consisted of interpreting small maxillary, sphenoidal and frontal sinuses as abnormal (Fig. 3) and misinterpreting minimal mucous membrane thickening of the maxillary sinuses (Fig. 4) and partial clouding of ethmoidal air cells (Fig. 5). Three frontal sinuses with early development appeared cloudy on plain radiographs but normal on CT scans.

All patients had ethmoidal and maxillary sinus development. Those patients with frontal and sphenoidal sinus development are listed in Table 1. Only four frontal sinuses were abnormal.

Fig. 2.—Caldwell projection radiographs of a 4-year-old (A) and a 2-year-old (C) that seem to show ethmoidal disease. Representative CT scans (B, D) show no evidence of ethmoidal disease.

Fig. 3.—A, Waters projection radiograph of a 12-year-old boy interpreted as partial opacification of right maxillary sinus. B, Coronal CT scan is normal except for a smaller right maxillary sinus.
on CT scans. No bone destruction was noted. Only 12 of 70 patients had no sphenoidal sinus development on CT. The youngest patient with sphenoidal sinus development was 1 year 10 months old [2]. All but one of the nine patients thought to have sphenoidal sinus clouding by plain radiographic findings, but with normal findings on CT scans, were less than 4 years old. No cases of isolated sphenoidal sinus disease were seen. Fifteen sphenoidal sinuses had soft-tissue disease shown on CT scans. The lateral film was useful in evaluating the size of the adenoids, but was of no value in patients less than 3 years old and tended to overestimate sphenoidal clouding in patients between 3 and 5 years old. The submen- tovertebra radiograph was added on patients 6 years old and older and was of value in only one patient with a hypoplastic maxillary sinus.

In the evaluation of ethmoidal sinuses and maxillary sinuses by CT, it was found that of the 70 patients, 47 (67%) had ethmoidal abnormalities on CT, whereas maxillary sinuses were abnormal in 44 (63%). Twelve (26%) of the 47 patients with normal ethmoidal sinuses had normal maxillary sinuses, and 11 (25%) of 44 patients with abnormal maxillary sinuses had normal ethmoidal sinuses. Soft-tissue disease, mucous membrane thickening, and secretions in the nasal cavity noted on coronal CT scans were poorly shown on plain radiographs.

Ethmoidal sinus involvement was not accurately localized on plain radiographs, but was shown on CT scans (Fig. 6). Sagittal reconstructions through the ethmoidal sinuses were useful for measuring distances between the inferior nasal spine and the top of the ethmoidal air cells or distance to the sphenoidal sinuses or to help localize ethmoidal disease (Figs. 6D and 6E). Plain radiographs were not useful for detecting prior endoscopic surgery (Fig. 7). Although all paranasal sinus radiographs and coronal CT scans were reviewed by one of the authors, the original interpretations were used for the study. There was little discrepancy with the interpretations of the CT scans. Some variation existed in the interpretations of paranasal sinus radiographs, but the overall results were not appreciably altered.

Discussion

A number of investigators believe that recurrences of sinusitis are related to residual anterior ethmoid disease [3, 4]. This residual disease could spread and lead to persistence of
local infection in the middle meatus of the nose, which is near the anterior end of the middle turbinate. Infection in the anterior ethmoid-middle meatus complex (ostomeatal complex) could disrupt normal mucociliary clearance of the anterior ethmoidal, maxillary, and frontal sinuses, thus leading to chronic recurrent sinusitis [5, 6]. If diseased tissue in the ethmoidal area and common drainage site in the middle meatus is removed by endoscopic surgery and mucociliary clearance and ventilation are returned to normal, the maxillary and frontal sinuses also may clear [4].

Doubt has been cast on the utility of conventional radiographs for accurately depicting the extent and location of...
sinus disease and for directing this surgical approach to recurrent chronic sinusitis [7, 8]. Our prospective study compared sinus radiographs with coronal CT scans. The assumption was made that coronal CT scans accurately depict sinus anatomy and disease. The plain radiographs both underestimated and overestimated sinus disease.

Ethmoidal, sphenoidal, and maxillary sinus mucous membrane thickening or opacification noted on plain radiographs was not documented on CT scans. The appearance of partial ethmoidal clouding may occur on the Caldwell projection, possibly caused by superimposed ethmoidal air cells, slight rotation, nasal secretions, mucous membrane thickening, and variations in plain radiographic techniques. The sloping lateral and superior maxillary sinus walls can be interpreted erroneously, as mild mucous membrane thickening. The angulation required to image maxillary sinuses can result in double contours, simulating maxillary sinus disease. A hypoplastic maxillary or a small frontal sinus can appear to be diseased. Anterior ethmoidal air cells in the Waters projections often appeared cloudy, but frequently appeared normal on CT scans. Small normal sphenoidal air cells can appear partially opacified on lateral sinus radiographs.

Partial ethmoidal disease noted on CT scans may not be shown on conventional radiographs. This is not unexpected when plain radiographs and CT scans are compared elsewhere in the body. The agreement between plain radiographs and CT scans was best in the maxillary sinuses, although minimal to modest mucous membrane thickening, especially posteriorly, or posterior retention cysts may not be evident on plain radiographs.

Some clinicians request only a Waters projection when evaluating a patient for sinusitis. In our study, 23% of the patients with normal maxillary sinuses had ethmoidal sinuses that were abnormal on CT scans, thus casting doubt on the value of a Waters projection in excluding sinus disease. In 25% of the patients with maxillary sinus clouding on Waters projections confirmed by CT, the ethmoidal sinuses were normal.

Lateral sinus radiographs in children less than 3 years old were found to be of little value, and we have dropped this projection from our plain film routine. Submentovertex projections contributed little diagnostic information in this group of patients, but this may not be the case if one is examining for possible nasopharyngeal tumors.

This study did not address the controversial issue of the significance of soft-tissue sinus disease seen on CT scanning done for reasons other than clinical sinus disease [9, 10]. The patients studied all had clinical recurrent sinusitis but were asymptomatic at the time of the examinations. Although the exact number of discrepancies between plain radiographs and coronal CT scans would be different had another group of radiologists performed the interpretations, we feel the overall findings and conclusions would remain. This study does not negate the value of plain radiographs in the evaluation of sinus disease in children, especially in the presence of clinical acute sinusitis, but does show limitations of paranasal sinus radiographs in the diagnosis of sinus disease, particularly of the ethmoidal and sphenoidal sinuses and of their use in directing endoscopic surgery.

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REFERENCES