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Limited CT scanning techniques of the paranasal sinuses

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Abstract
Computerized tomographic (CT) imaging provides detailed information on the paranasal sinuses and is now well established as an alternative to standard radiographs. The planning and safety of surgery to the paranasal sinuses is greatly improved by CT imaging. We describe a new CT protocol comprising a limited coronal and axial scan series, based on our experience with the previously described 'CT Mini-series'.

Introduction

The use of limited CT scanning techniques of the paranasal sinuses is now well established as an alternative to standard paranasal sinus radiographs (Chow and Mafee, 1989; White *et al.*, 1990). In this paper we describe a new CT protocol based on our experience with the previously described 'mini-series'.

A complete axial and coronal CT scan series provides an excellent and comprehensive evaluation of the paranasal sinuses but is expensive and time consuming to perform, especially when older scanners are used (Zinreich *et al.*, 1987). Standard paranasal sinus radiographs provide a rapid and convenient alternative, but fail to demonstrate accurately the clinically important ethmoid sinus complex and ostiomeatal unit (Hilding, 1944; Carter *et al.* 1983). Pluridirectional tomography is more reliable than plain films but is inferior to CT. Limited CT scans offer a compromise by providing the good bone and soft tissue definition of CT, at little greater cost than standard radiographs (White *et al.*, 1990).

The 'CT Mini-series' comprises four specific slices of the maxillo-facial region. A single scout view is used to strategically place each individual slice. When necessary the planes of slices are manipulated slightly to avoid dental filling artefact. Precise placement of the slices requires a specialized knowledge of radiological anatomy necessitating the presence of a radiologist. Even using skilled techniques, extra slices are frequently required because of incorrect placement, although the investigation can be performed within 15 minutes.

A major disadvantage of the mini-series technique is that the slice numbers are small (three coronal slices plus one axial), offering limited visualization of the clinically important ostiomeatal complex. In our experience the considerable variation in sinonasal anatomy makes it impossible to predict the location of the antral ostium from the scout view. The 'Screening Coronal Section CT Scan' described by Chow and Mafee (1989) comprising seven to eight coronal slices improves imaging of the ostiomeatal complex, but fails to provide axial plane images. Information gained from the axial slices (Van Alyea, 1941; Carter *et al.*, 1983) should not be overlooked if the complications of surgery are to be minimized. Important relations such as those of the internal carotid artery and the optic nerve to the spheno-ethmoid complex are much more easily appreciated in the axial plane. In addition, we feel that the spheno-ethmoid recess is much more easily assessed by axial imaging.

We have modified the original 'mini-series' technique simply by accepting an increase in slice numbers. Radiological supervision for slice placement is not required, the investigation being performed reliably by a trained radiographer.

Method

The Modified CT Mini-Series comprises six to eight coronal slices and two or three axial slices of the maxillo-facial region. On our General Electric 8800 scanner the patient lies supine on an elevating box with neck extended as much as is comfortable, with gantry angulation if necessary to get as close as possible to a true coronal plane. Five millimetre slices spaced 10 mm apart are obtained from the bridge of the nose to the middle of the sphenoid sinus region (Fig. 1a). Axial slices are obtained with the patient lying supine on the scanner table with the orbitomeatal baseline roughly perpendicular to the table and gantry angulation to scan parallel to the hard palate. Another scout film is obtained and then 5 mm slices are scanned at 10 mm intervals from the level of the posterior clinoids to the floor of the sphenoid sinuses (Fig. 1b). Radiographic factors will vary between scanners but we have found a low mA (*e.g.* 250) gives adequate detail while minimizing scanning time. This is important as the position for the coronal scans is quite uncomfortable for the patient. Patients who cannot tolerate the coronal scanning position are scanned with contiguous 5 mm axial slices from the top of the frontal sinus to the bottom of the antra; this is far from ideal but is still a great improvement over plain films for accurate

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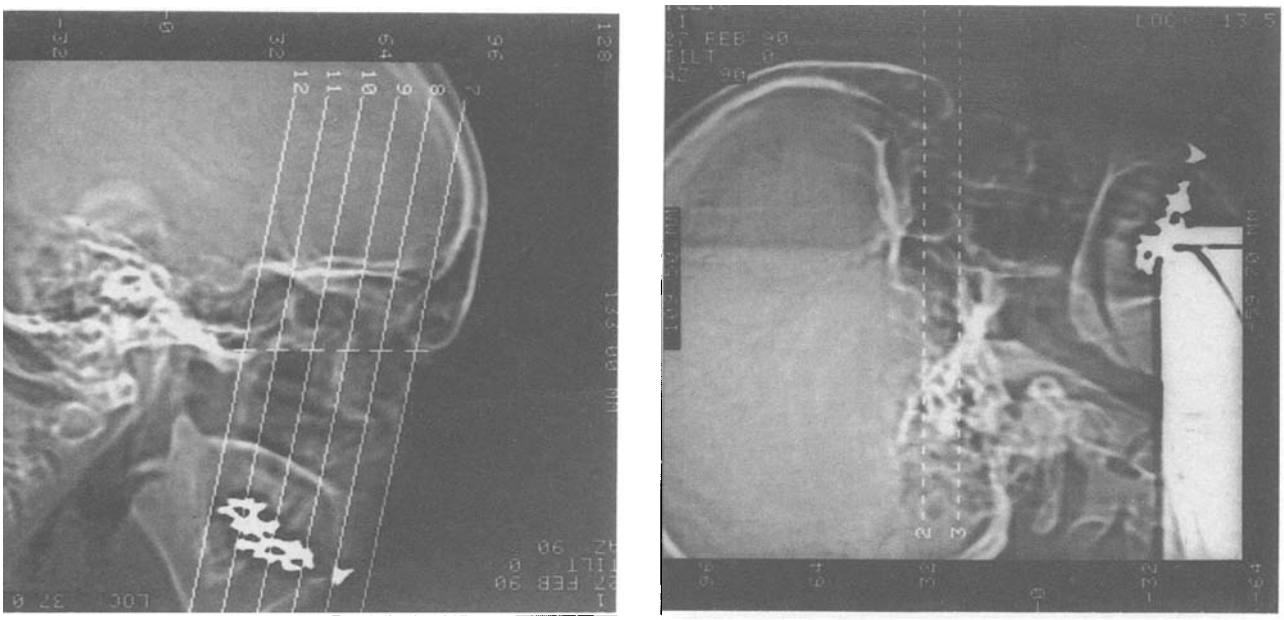

FIG. 1

Scout views for coronal series (a) and axial series (b), showing the number and direction of slices obtained.

demonstration of anatomy and pathology. The images are re-targeted using a soft-tissue algorithm and magnified to about twice their original size, and then photographed using a level of zero and a window of 2000 HU, although these settings may be varied in the presence of extensive metallic artefact from dental fillings (higher level often better), or very extensive soft tissue abnormalities (narrower window *e.g.* 1200). Figure 2 shows a modified CT mini-series of a patient with ethmoidal sinusitis and secondary involvement of the frontal and maxillary sinuses.

Discussion

Modern theories of the origin of rhinogenic sinusitis heavily implicates the ostiomeatal unit. This term popularized by Messerklinger and Stammberger (Messerklinger, 1982; Stammberger, 1986) includes the frontal

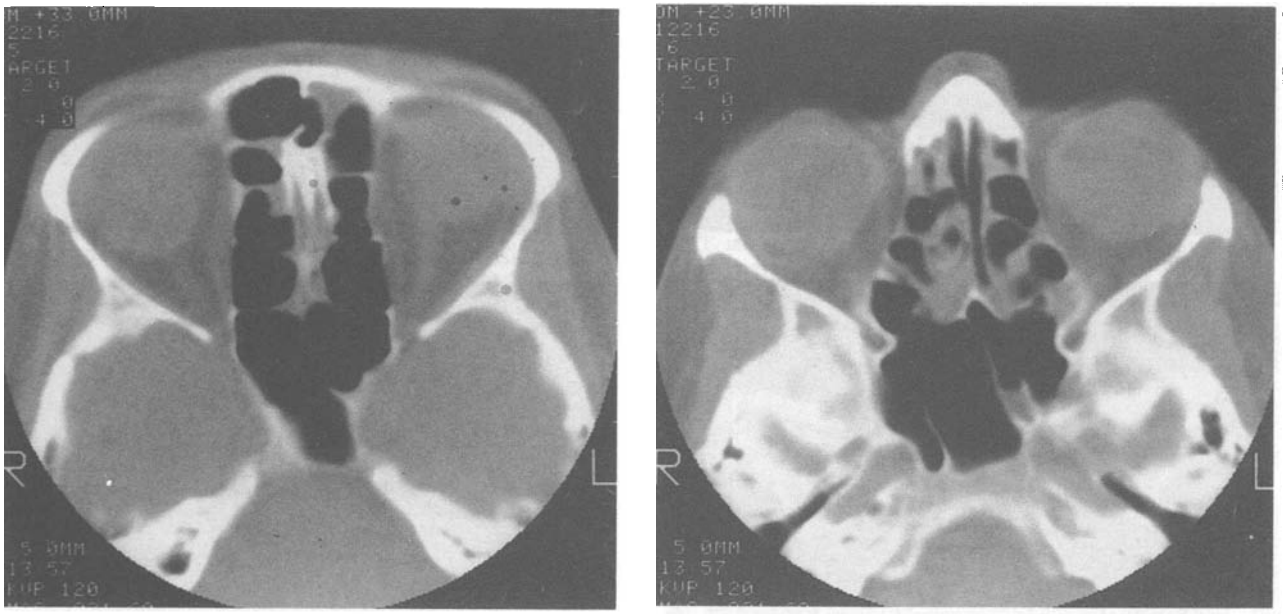

FIG. 2

Axial series (a) and coronal series (b); the report generated from these images reads as follows: On the left side there is fluid in the frontal sinus with disease in the adjacent anterior ethmoid cells. The middle ethmoid cells appear normal but there is scattered mucosal thickening in posterior ethmoid cells. The spheno-ethmoid recess is occluded and there is a little fluid in the sphenoid sinus. There is polypoid mucosal thickening in the maxillary antrum and the ostiomeatal unit is occluded by soft tissue swelling. The ethmoid bulla is completely opaque. There is some pneumatization of the orbital roof by ethmoid cells, but these are not opaque. On the right side the frontal sinus is clear but there is disease in most of the ethmoid sinuses. The antrum has some polypoid mucosal thickening within it and the ostiomeatal unit is blocked. The spheno-ethmoid recess is blocked but the sphenoid sinus appears clear. The orbital roof contains some ethmoid air cells, but these are clear. The cribriform plate lies about 5 mm below the roof of the ethmoid block. There is no significant disease in posterior ethmoid cells adjacent to the orbital apex on either side. The carotid siphons are well covered by bone.

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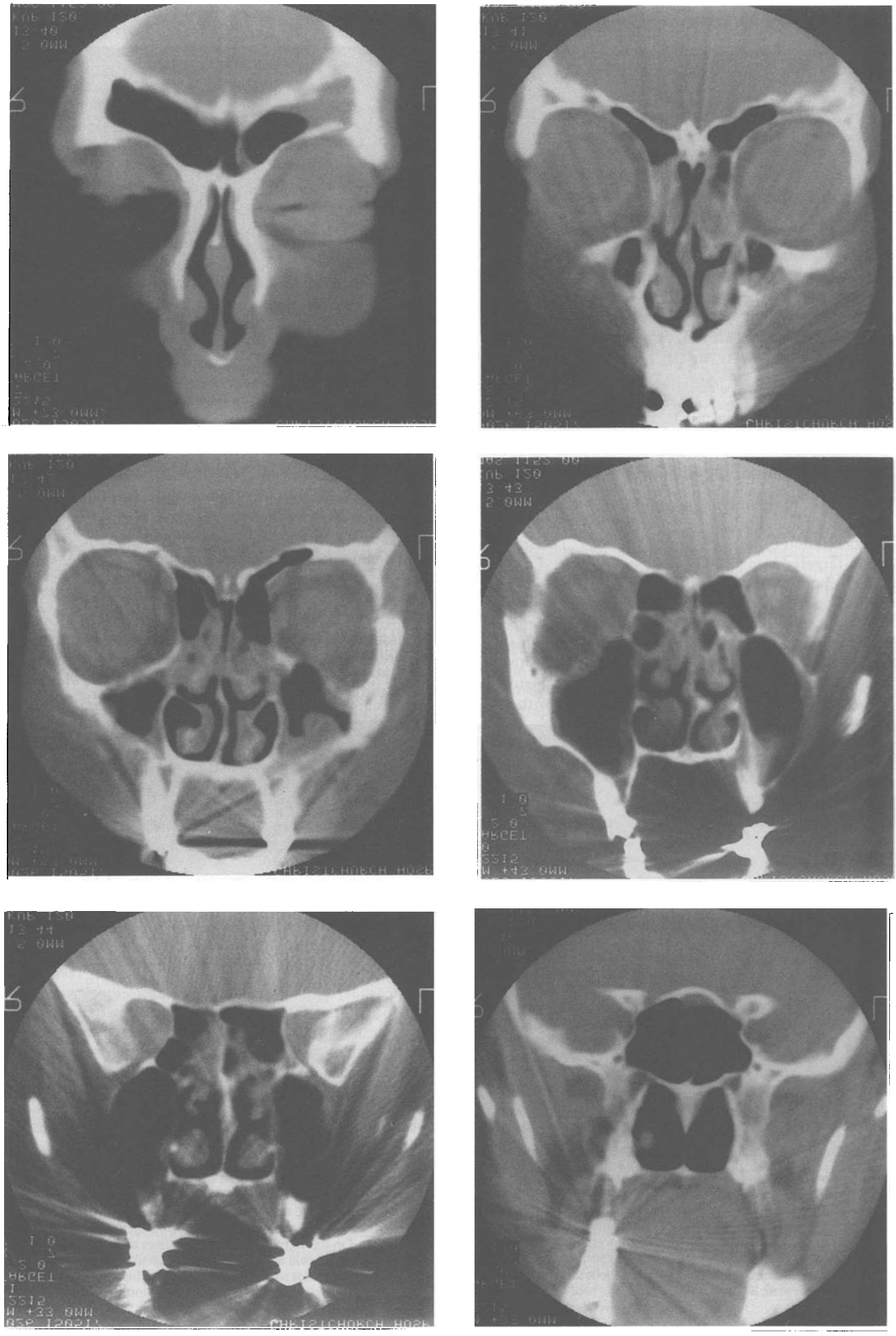

FIG. 2b.

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recess, maxillary sinus ostium and infundibulum, all of which open onto the middle meatus of the nose. Chronic infection in the maxillary and frontal sinuses usually results from interference in the mucociliary clearance of the ostiomeatal unit and anterior ethmoid complex (Hilding, 1944; Messerklinger, 1967; Stammberger, 1986). The posterior ethmoidal sinuses and the sphenoidal sinus drain into the spheno-ethmoid recess, and mucociliary impairment here, is similarly implicated in the aetiology of infection in these sinuses.

Standard paranasal sinus radiographs have been the traditional initial investigation of choice for the diagnosis of paranasal sinus disease. Unfortunately plain radiographs fail to show the clinically important ethmoid sinus complex and ostiomeatal unit with any accuracy (Zinreich, 1987), CT imaging is the preferred modality for the evaluation of paranasal sinus disease especially if endonasal sinus surgery is planned. Economic constraints in many centres have reduced the availability of CT (White *et al.*, 1990). Limited CT scanning techniques have evolved as a cost and time efficient alternative to a full paranasal sinus coronal and axial CT series.

We have evaluated two forms of limited CT scanning, the 'CT Mini-Series' and the 'Screening Coronal Section CT Scan', and find that both techniques have their deficiencies. The CT Mini-Series with only three coronal slices does not provide enough information for accurate diagnosis and surgical planning. The screening coronal CT scan, while providing adequate numbers of coronal slices, fails to image in the axial plane.

We believe the axial plane information is essential for adequate assessment of the spheno-ethmoid recess and of the surgical relations of the internal carotid arteries and optic nerves. Studies on the relationships of these structures to the posterior ethmoidal and sphenoidal sinuses (Fujii *et al.*, 1979; Teatini *et al.*, 1987) show that in most subjects the nerve is closely related to both sinuses, while the artery lies in close proximity to the sphenoidal sinuses. The bone thickness separating each of these adjacent structures from sinus mucosa is frequently less than 0.5 mm. Bony dehiscences over the artery or nerve occur with a frequency of 4 per cent. Cadaver dissections suggest dehiscences over the artery may be considerably higher, approaching 15 to 20 per cent. (D. W. Kennedy: personal communication). Pre-operative knowledge of these relationships is essential for safe endonasal spheno-ethmoid surgery. Prior to the availability of the rigid endoscope and CT, the fear of complications such as blindness and death resulted in many surgeons avoiding endonasal ethmoidectomy completely (Harrison, 1971; Eichel, 1972 ; Freedman and Kern, 1979), (and this situation should not be repeated).

The addition of two or three axial slices to a limited coronal series we feel justifies the minimal extra impingement on scanner time. We advocate a modification of the previously described limited CT techniques, comprising an average ten slice series which images in both the coronal and axial planes.

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