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The paranasal sinuses before and after radiotherapy for nasopharyngeal carcinoma: a computed tomographic study

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Abstract

A study comparing the pre- and post-radiotherapy computed tomographic scans of patients treated for nasopharyngeal carcinoma revealed that the incidence of major mucosal abnormality was significantly increased and approximately doubled after radiotherapy. The most significant factor predicting major mucosal abnormality after radiotherapy was the presence of tumour in the sinus before treatment. In the maxillary sinus there was significant association of major mucosal abnormality before and after radiotherapy although this was not so for the other sinuses. The mucosal changes observed were evident as early as six months after radiotherapy.

Key words: Nasopharyngeal neoplasms, carcinoma; Tomography, computerised axial; Paranasal sinuses; Radiotherapy

Introduction

Nasopharyngeal carcinoma (NPC) is endemic in Southern China including Hong Kong. The standardized annual incidence rate is 23.8 per 100,000 males and 10.5 per 100,000 females (Hong Kong Cancer Registry, 1993). Unlike most other head and neck cancers, the principal treatment modality for NPC is radiotherapy to both the primary site and regional lymph nodes. The paranasal sinuses are sometimes invaded by local spread of tumour (Fletcher, 1978). Even when the tumour is small, part of the sinuses are routinely included within the radiotherapy portals to give adequate margins for confident tumour coverage. Little is known, however, about the effect of radiotherapy on the paranasal sinuses although nasal symptoms, in the form of nasal obstruction, discharge and dryness, are common after radiotherapy.

The purpose of this study is to determine the effect of radiotherapy for NPC on the prevalence of mucosal disease of the sinuses, as judged by computed tomography (CT).

Methods and materials

This retrospective study examines the CT scans of forty-nine patients who had radiotherapy for NPC at the Prince of Wales Hospital, Hong Kong. A CT scan is a routine staging investigation for NPC. However, as post-radiotherapy scans are performed selectively, the patients in this study were included according to the availability of a follow-up scan. These follow-up scans were performed either as part of a prospective study of the cerebral complications of radiotherapy or for suspected recurrent tumour. Exclusion criteria were: proven recurrent disease in the nasopharynx or sinus at the time of, or within 12 months after the post-radiotherapy scan and patients with less than twelve months follow-up. The number of sinuses within the five sets of sinuses was different because not all sinuses were visualized on every scan.

The CT scans were performed on a GE 8800 scanner. Axial sections were taken in the orbitomeatal plane 5 mm thick, formatted at a level of 200 with a window width of 2,000. The radiotherapy technique used has been described in previous publications (Ho, 1982). The whole of the sphenoid sinus and the posterior halves of the maxillary and ethmoid sinuses lay within the target volume of the radiotherapy portals. These regions received a radiation dose of 66 Gys. In patients with significant anterior extension of the disease into the nasal cavity, maxillary sinus or ethmoids, the radiation portals extend to cover the whole of the maxillary and ethmoid sinuses.

The interval between the scans averaged 40 months (range seven to 69 months). The scans

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were analysed for the degree of mucosal disease in each of the five sinuses on both sides: maxillary, frontal, sphenoid, anterior and posterior ethmoids. A score was given for each sinus after the method of Lloyd *et al.* (1991): 0 = no mucosal disease; 1 = minor mucosal thickening; 2 = major mucosal thickening; 3 = sinus opacity or fluid level; 'T' = sinus involvement with tumour.

The designation 'T' was given whenever there was suggestion of the sinus being invaded by tumour. The criteria for this were both clinical and radiological. All patients had nasal endoscopy and these findings were considered when assigning a score. Radiological criteria were:

(i) bony destruction in the wall of the sinus;
(ii) direct continuity with the tumour mass;
(iii) invasion or expansion of the pterygomaxillary fissure (maxillary sinus).

All sinus scores were assigned by the consensus of a meeting with an otolaryngologist (M.J.P.), two radiologists (H.C. and R.O.) and a radiotherapist (S.F.L.).

The results were analysed statistically by the Fisher Exact Test.

Results

Patient and disease characteristics are summarized in Table I. As the diagnosis of minor mucosal thickening is somewhat subjective and probably of little clinical significance compared to major thickening or opacity, the results were analysed by defining a 'low-score' category comprising sinuses with scores of 0 or 1, and a 'high-score' category with scores of 2 or 3.

Pre-radiotherapy sinus abnormalities

Figure 1 shows that the posterior ethmoids had a significantly higher incidence of high-score than the other sinuses before radiotherapy ($p<0.01$, chi-squared test for association). The sphenoid sinus was the sinus most commonly involved by tumour, Table II ($p<0.01$, chi-squared test for association).

Post-radiotherapy vs *pre-radiotherapy scans*

Sinuses without tumour involvement pre-radiotherapy were analysed. Figure 1 shows that the incidence of high-score was more than doubled in all the sinuses after radiotherapy. The differences between the pre- and post-radiotherapy scans are statistically significant for all the sinuses ($p<0.01$) except the frontal ($p = 0.08$). For sinuses with a low score pre-radiotherapy, a comparison among the sinuses shows that the frontal, anterior ethmoid and maxillary sinuses were less likely to deteriorate than the sphenoid and posterior ethmoid sinuses (Table III, data column on 'deterioration'). However, as far as individual sinuses are concerned, there was no significant association between high scores on the pre- and post-radiotherapy scans, except for the maxillary sinus where a high pre-radiotherapy score tended to be associated with a high post-radiotherapy score ($p = 0.05$) (Table III). Thus the degree of mucosal thickening in a sinus on pre-treatment CT scan did not help to predict the post-radiotherapy changes except possibly in the case of the maxillary sinus.

Sinuses with tumour involvement before radiotherapy had a higher probability of significant mucosal thickening (24/33; 73 per cent) after radiotherapy compared to sinuses not involved by tumour originally (129/408; 32 per cent). The difference is statistically significant ($p<0.01$).

The total sinus scores for each patient as determined on the post-radiotherapy scan were plotted against the time interval post-radiotherapy (Figure 2). There was no significant correlation between the score and the time after radiotherapy.

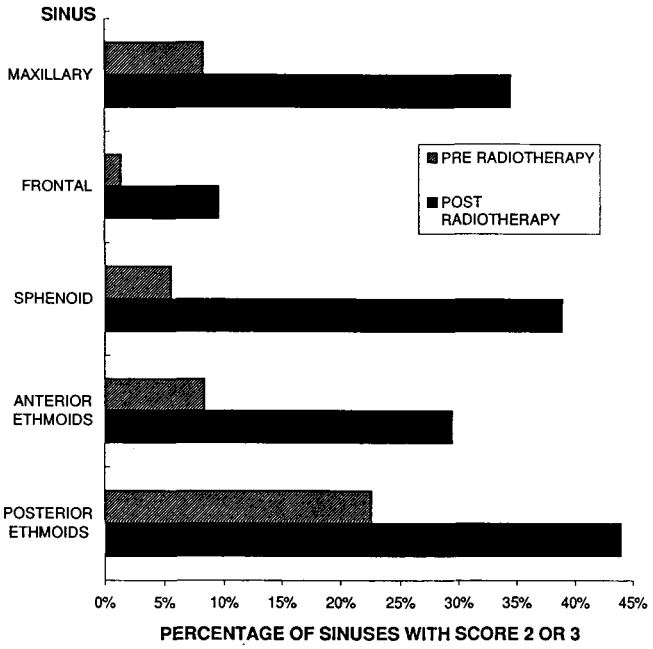

FIG. 1

The proportion of each sinus with high score (score 2 and 3) before and after radiotherapy (excluding sinuses with tumour involvement pre-radiotherapy).

TABLE I

DISTRIBUTION OF PATIENTS BY AGE, SEX AND TUMOUR STAGE

Number of patients	:	49
Mean age (range)	:	47 years (30–72)
Male:Female	:	2.5:1
Stage T1*	:	4
Stage T2*	:	23
Stage T3*	:	22

*Ho's stage-classification (Ho, 1978).

TABLE II

PROPORTION OF SINUSES WITH TUMOUR INVOLVEMENT BEFORE RADIOTHERAPY

Sinus	Number of sinuses surveyed	Number involved with tumour
Maxillary	84	0 (0%)
Frontal	73	0 (0%)
Sphenoid	94	22 (23%)
Anterior ethmoids	97	2 (2%)
Posterior ethmoids	93	9 (10%)

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TABLE III

RELATION BETWEEN PRE-RADIOTHERAPY AND POST-RADIOTHERAPY SINUS SCORES (SINUSES WITH TUMOUR INVOLVEMENT PRE-RADIOTHERAPY EXCLUDED).*

Sinus	Score pre-RT	Number	Score post-RT	Number	Post-score = pre-score	Post-score >pre-score (deterioration)	Post-score <pre-score (improvement)	Association of high pre- and post-RT score
Maxillary	low	77	low	53	69%			
			high	24		31%		
	high	7	low	2			29%	
			high	5	71%			$p = 0.05$
Frontal	low	72	low	65	90%			
			high	7		10%		
	high	1	low	1			100%	
			high	0	0%			$p = 1.00$
Sphenoid	low	68	low	42	62%			
			high	26		38%		
	high	4	low	2			50%	
			high	2	50%			$p = 0.64$
Anterior ethmoids	low	87	low	62	71%			
			high	25		29%		
	high	8	low	5			62%	
			high	3	38%			$p = 0.69$
Posterior ethmoids	low	65	low	37	57%			
			high	28		43%		
	high	19	low	10			53%	
			high	9	47%			$p = 0.74$

*The total number of sinuses differed as not every sinus was visualized on every scan. Low score = score 0 + score 1; high score = score 2 + score 3.

Discussion

Because of the anatomical relations of the nasopharynx, treatment for NPC involves exposure of several structures to high doses of radiation. While the late effects of radiotherapy on several organs have been described, that on the paranasal sinuses has not been reported previously.

A common complaint after radiotherapy is that of a stuffy nose often accompanied by purulent discharge. The results of this study confirm that major mucosal abnormalities are significantly increased after radiotherapy, suggesting that chronic sinus disease is a common late complication of radiotherapy and may be responsible for these symptoms. Much has been written on the normal mucociliary clearance mechanism and the pathways of sinus drainage (Stammberger, 1991). It is on this premise that current endoscopic sinus surgery is based. It is not surprising, therefore, that therapeutic doses of radiation which cause mucous membranes to become atrophic should predispose to chronic disease in sinuses. In some cases however, the pre-existing sinus disease will show improvement presumably as a result of effective tumour shrinkage, with consequent improvement in drainage. The appearance of the pre-treatment scan therefore has no value in predicting the eventual outcome. Whether the mucosal abnormality in a sinus would remain static, deteriorate or show improvement after radiotherapy cannot be predicted from the pre-treatment CT findings, with the exception of the maxillary sinus.

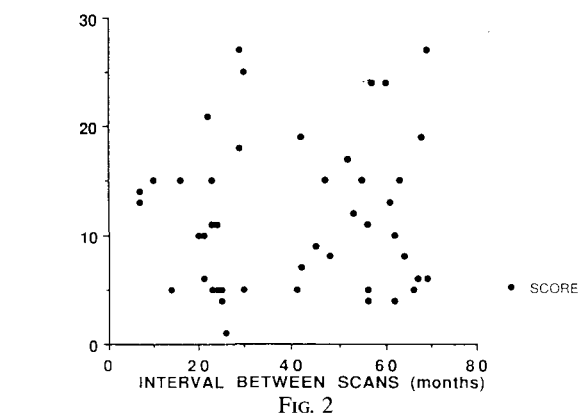

FIG. 2

Scattergram showing the total sinus score for each patient after radiotherapy against the interval between pre- and post-radiotherapy scans.

The higher probability of 'deterioration' of mucosal abnormalities in the sphenoid and posterior ethmoid sinuses is probably explained by their complete inclusion with the high-dose zone of the radiation portals. Deterioration also occurs in the frontal and anterior ethmoids although they are exposed to a lower dose of radiation from an anterior radiation beam during the treatment.

A limitation of the present study lies in the inherent difficulty of distinguishing mucosal thickening from tumour involvement in the pre-radiotherapy CT scan, short of biopsy confirmation. The authors attempted to minimize the potential error by reference to criteria such as presence of bone destruction, tumour in the pterygomaxillary fissure and endoscopic assessment findings. The authors also recognise that it is not possible to distinguish between recurrent tumour and benign mucosal disease on a post-radiotherapy CT scan. We, therefore, made the assumption that any abnormality seen on CT which did not clinically manifest itself as tumour recurrence within 12 months was benign mucosal disease. For this reason, only those patients who had 12 months of clinically disease-free follow-

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up were included. Whenever there was any doubt as to whether a sinus was involved with tumour either pre- or post-radiotherapy a designation of 'T' was given. Another limitation is the retrospective nature of the study with a selection of patients that is non-random. However the possible bias thus introduced is unlikely to be significant, since there is no evidence of an association between the indications for scanning and sinus abnormalities. On the basis of these findings we feel that a prospective study to observe the effect of radiotherapy on the sinuses, an evaluation of patients' symptoms, and active treatment of the sinus disease is indicated.

We conclude that patients who have radical radiotherapy for NPC are at risk of developing chronic sinus disease, which may occur relatively early after the treatment. Our study shows that it is generally difficult to predict which patient or sinus would be affected, though the sinuses that are invaded by tumour are particularly at risk. Thus specific assessment of sinus disease should be a routine part of the follow-up of these patients.

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