CT of Nasopharyngeal Carcinoma: Significance of Widening of the Preoccipital Soft Tissue on Axial Scans

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AJNR Am J Neuroradiol 1989, 10 (4) 839-844
http://www.ajnr.org/content/10/4/839

CT of Nasopharyngeal Carcinoma: Significance of Widening of the Preoccipital Soft Tissue on Axial Scans

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Axial CT scans of 60 patients with biopsy-proved nasopharyngeal carcinoma were reviewed with particular reference to sites of origin and routes of spread of disease. In all patients there was involvement of the pharyngeal space with blunting of the fossa of Rosenmuller and usually associated thickening of the adjacent levator veli palatini muscle. Tumor infiltration through the pharyngobasilar fascia manifested by obliteration or displacement of the parapharyngeal fat space was seen in 65% of the patients. T-staging by CT showed T1 (28%), T2 (20%), T3 (5%), and T4 (47%) involvement. In three patients there was bilateral symmetric blunting of the fossa of Rosenmuller with no evidence of tumor infiltration into the paraphyngeal space. The scans were initially interpreted as normal except for widening of the preoccipital soft-tissue area in the midline of more than 1.5 cm and up to 2.0 cm in the anteroposterior plane. Biopsy of the postnasal space was positive for tumor in these patients. With symmetric, early stage nasopharyngeal carcinoma, a confident radiologic diagnosis on CT can be difficult. If there is asymmetry of pharyngeal mucosal space or evidence of deep infiltration this should not be a problem.

Although lymphoid adenoid tissue can sometimes result in widening of the preoccipital area, it is proposed that widening of this area of greater than 1.5 cm is an additional CT sign of nasopharyngeal carcinoma not previously emphasized. It is the result of early submucosal infiltration of the disease, and a patient with clinically suspected nasopharyngeal carcinoma should have aggressive deep biopsies of the fossa of Rosenmuller.

CT has been the most reliable and well-established imaging technique for staging and assessing the extent of nasopharyngeal carcinoma (NPC) [1–3], although MR imaging is now replacing CT as the examination of choice in the nasopharynx. NPC has a tendency for submucosal spread, and diagnosis of the disease is usually not difficult on CT scans. The typical finding is asymmetry of the fossa of Rosenmuller manifested as blunting or obliteration, often with associated thickening of the deglutitional muscle layer caused by tumor infiltration [4] (Fig. 1). As NPC characteristically results in deep infiltration, there is often obliteration or displacement of the parapharyngeal space (Fig. 2).

Materials and Methods

Axial CT scans of 68 patients with clinically suspected NPC were reviewed. All scans were obtained to aid in the diagnosis and to assess extent of disease infiltration. In 18 patients, scans were acquired to reassess recurrence of disease after radiotherapy. All patients underwent postnasal space biopsy of the fossa of Rosenmuller to confirm the presence of disease. In 60 patients disease was proved histologically. These patients consisted of 40 males and 20 females, 11 to 76 years old (mean, 48 years).

All scans were performed on a Picker 1200SX scanner. Contiguous axial scans, 5-mm thick, were obtained parallel to the hard palate, from a level of about 2 cm below the hard palate and extending cranially to the base of the skull up to the inferior orbital margin. Only contrast-enhanced scans were obtained, immediately after a bolus IV injection of contrast medium (50 ml Urografin 76).* Owing to demands on scanner time, scans were not routinely

*Schering AG, West Germany.

This article appears in the July/August 1989 issue of *AJNR* and the October 1989 issue of *AJR*.

Received July 19, 1988; revision requested September 9, 1988; revision received November 25, 1988; accepted December 7, 1988.

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***AJNR* 10:839–844, July/August 1989**
0195–6108/89/1004–0839


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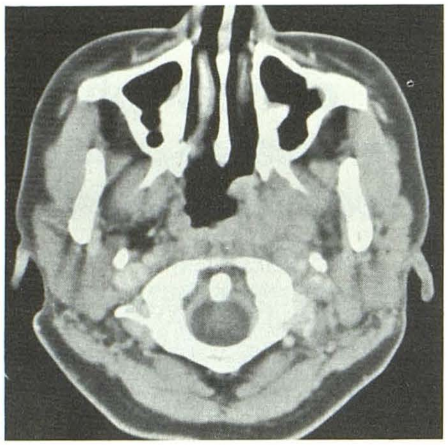
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Fig. 1.—Example of early nasopharyngeal carcinoma. There is blunting of left fossa of Rosenmuller and enlargement of levator palatini muscle. Although there is asymmetry of superficial mucosal contours of nasopharynx, the changes can be quite subtle.

Fig. 2.—Tumor has spread through pharyngobasilar fascia to involve parapharyngeal fat space. Note that normal fat density of this space is partly obliterated and that there is obvious asymmetry of the fossa of Rosenmuller.

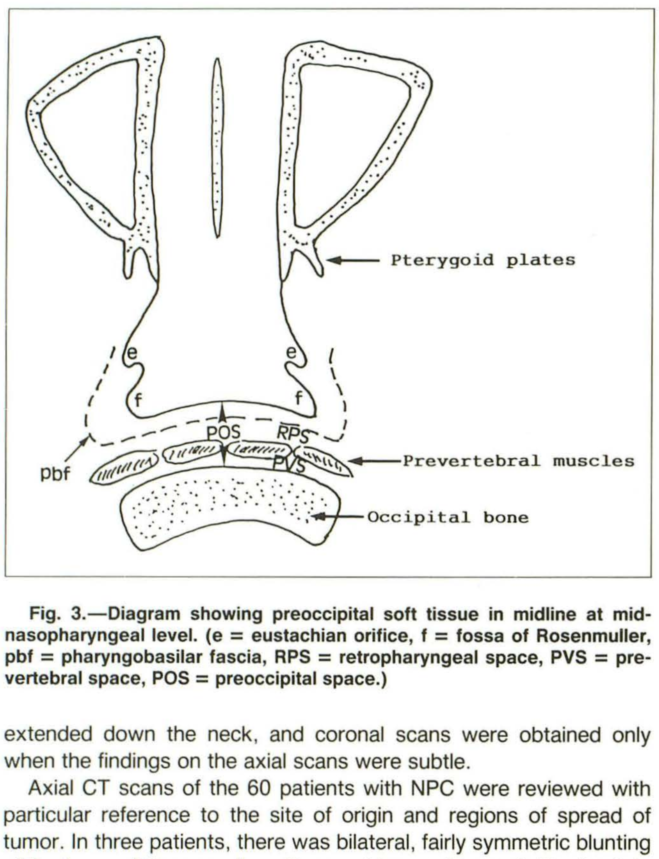


Fig. 3.—Diagram showing preoccipital soft tissue in midline at mid-nasopharyngeal level. (e = eustachian orifice, f = fossa of Rosenmuller, pbf = pharyngobasilar fascia, RPS = retropharyngeal space, PVS = prevertebral space, POS = preoccipital space.)

extended down the neck, and coronal scans were obtained only when the findings on the axial scans were subtle.

Axial CT scans of the 60 patients with NPC were reviewed with particular reference to the site of origin and regions of spread of tumor. In three patients, there was bilateral, fairly symmetric blunting of the fossa of Rosenmuller with no evidence of tumor infiltration into the parapharyngeal space. There was initial difficulty in diagnosing confidently the axial scans as abnormal. An associated widening of the preoccipital soft tissue in the midline at the mid-nasopharyngeal level of more than 1.5 cm on axial scans was found in these patients (Fig. 3). Although physiologic maneuvers and coronal scanning may help in differentiating normal from abnormal superficial mucosal masses of the nasopharynx, it appears that this widening of the preoccipital soft tissue is a useful additional sign to aid in the CT diagnosis of early NPC, which has not been emphasized previously.

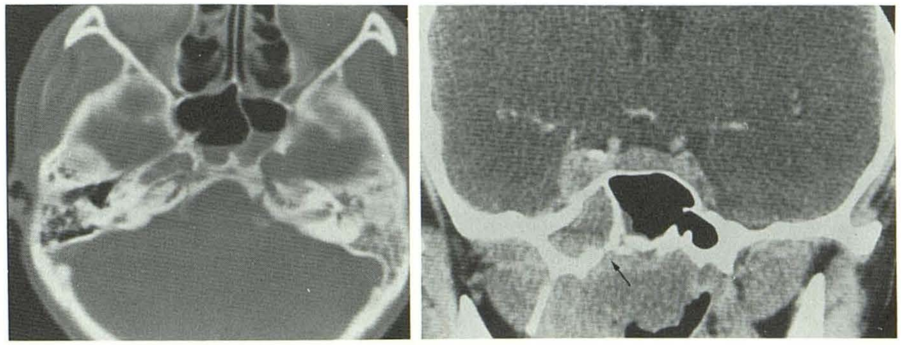
Results

In assessing the spread of tumor, infiltration was evaluated in terms of involvement of spaces of the nasopharynx, which are spaces compartmentalized by the deep cervical fascia. In all 60 patients there was involvement of the pharyngeal mucosal space with blunting of the fossa of Rosenmuller. Bilateral blunting of the fossa was seen in six patients.

Once the disease has invaded the pharyngobasilar fascia there is involvement of the parapharyngeal space. This was seen in 65% of patients in whom there was obliteration of the normal fat density of the space or lateral displacement. Beyond this area direct spread of NPC can be anteriorly to the masticator space, laterally to the parotid and carotid spaces, posteriorly to the retropharyngeal and prevertebral spaces, or superiorly to the skull base.

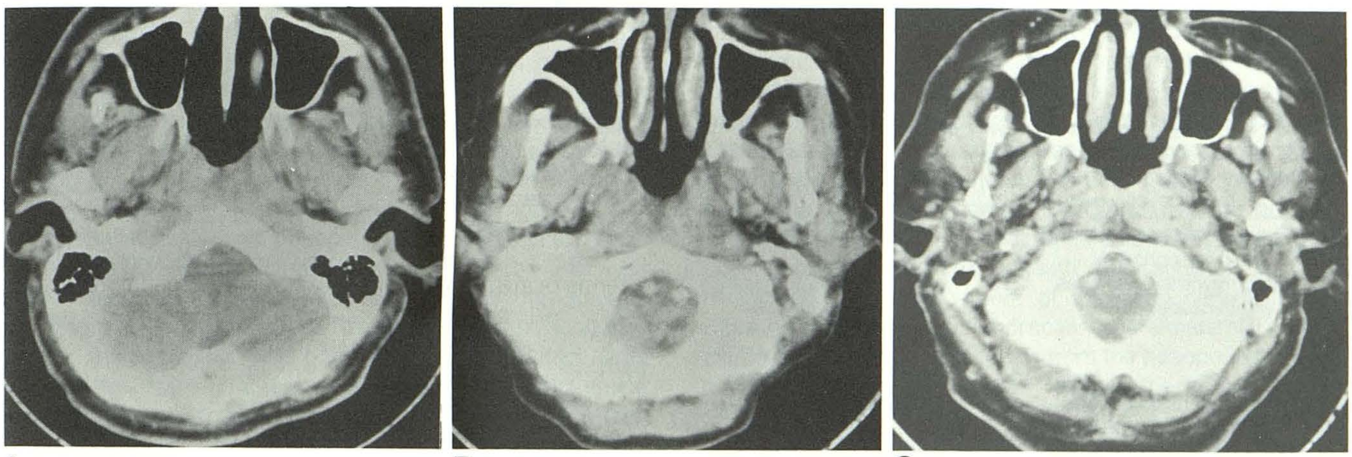
Superior intracranial extension was the most common region of spread of disease and was seen in 48% of patients. Opacification of the sphenoid sinus, infiltration of the cavernous sinus, and bony destruction of the base were common findings in most patients (Fig. 4). The most common areas of bony destruction were the base of the sphenoid bone and the clivus, the foramen lacerum, with the adjacent middle cranial fossa, and the foramen jugulare. Posterior spread of NPC to the retropharyngeal space was the next most common site and seen in 40% of patients. More posterior spread to the prevertebral spaces was seen in 15%, while spread to the masticator space, parotid space, and inferior spread of disease deep to the tonsillar pillars was less common.

In three patients, bilateral, fairly symmetric blunting of the fossa of Rosenmuller was seen with no definite evidence of a soft-tissue density tumor mass either laterally or in the midline anterior to the prevertebral muscles. There was no evidence of tumor infiltration into the parapharyngeal spaces, which appeared to be preserved (Fig. 5). There was initial difficulty in diagnosing confidently the axial scans as abnormal, although in one patient there was suspicion of an en-



A B

Fig. 4.—*A* and *B*, On axial scan (*A*) there is opacification of the sphenoid sinus. Destruction of sphenoid sinus floor by direct infiltration of tumor is confirmed on coronal scan (*arrow* in *B*).



A B C

Fig. 5.—*A–C*, In the three cases shown, all biopsy-proved nasopharyngeal carcinoma, there is bilateral blunting of the fossa of Rosenmuller and no obvious asymmetry of mucosal airway contour. The preoccipital space is widened. In *C*, on the left side, there is a soft-tissue density lateral to the prevertebral muscles near the carotid artery. It could represent a metastatic retropharyngeal lymph node.

larged retropharyngeal lymph node (Fig. 5C). The preoccipital soft-tissue width (POS) was reviewed in all patients. This was defined as the maximum anteroposterior width of the soft-tissue density in the midline, at the mid-nasopharyngeal level, with the anterior border being the mucosal surface of the pharyngeal mucosal space and the posterior border being the occipital bone (Fig. 3).

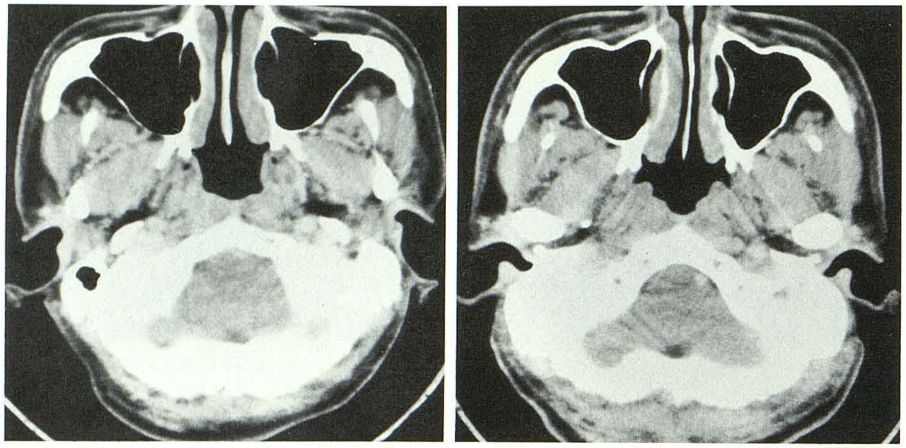
An associated widening of the preoccipital soft tissue of more than 1.5 cm on the axial scans was found in these three patients, the POS measuring 1.5 cm, 2.0 cm, and 1.8 cm, respectively. Postnasal space biopsy was positive for NPC in these three patients who had positive biopsies bilaterally. Abnormality of the mucosa of the postnasal space bilaterally in these patients was also visualized by the surgeon at the time of biopsy. When the POS was measured in the other 57 patients, the average width was 1.47 cm (range, 0.4–3.0 cm). Note that this widening of the POS could not be identified on the lateral scout views.

Of the 68 patients reviewed in this study, two were biopsy-negative for NPC, although their scans showed apparent blunting of the fossa bilaterally with no widening of the POS (Fig. 6).

T-staging of the disease by CT was also recorded. Criteria used for T-staging NPC were as specified by the American Joint Committee for Cancer (AJCC) and also after Ho's classification [5, 6] (Table 1). The results of T-staging by CT are as shown in Table 2.

Table 3 lists the compartments and spaces of the nasopharynx. The medial compartment of the nasopharynx contains the pharyngeal mucosal space. For involvement of this space, asymmetry of the fossa of Rosenmuller was looked for, especially with associated enlargement of the levator veli palatini muscle.

The lateral compartment of the nasopharynx contains the parapharyngeal space, the masticator space, and the parotid and carotid spaces. The masticator space is situated anteriorly and contains the infratemporal fossa in its cephalic aspect. It is bounded medially and laterally by the superficial layer of deep cervical fascia and contains the muscles of mastication and body of the mandible [7]. The parotid space is posterolateral to the parapharyngeal space and contains the parotid gland. The carotid space is retrostyloid and formed by the carotid sheath; it contains the internal carotid artery and jugular vein and lymph nodes of the deep cervical chain.



A B

Fig. 6.—*A* and *B*, In these two cases there is bilateral blunting of the fossa of Rosenmuller. The preoccipital space is less than 1 cm. Biopsies of the postnasal space were negative for tumor.

TABLE 1: T-Staging of Nasopharyngeal Carcinoma

American Joint Committee Classification		Ho's Classification	
T1	Tumor confined to one site within nasopharynx	T1	Tumor confined to nasopharynx
T2	Tumor involving two sites within nasopharynx	T2	Tumor extends to nasal fossa, oropharynx or adjacent muscles, or nerves below base of skull
T3	Tumor extension beyond nasopharynx to neighboring soft tissues (oropharynx, nasal cavity)	T3a	Bone involvement below base of skull (floor of sphenoid sinus is included in this category)
		T3b	Involvement of base of skull
		T3c	Involvement of cranial nerves
		T3d	Involvement of orbits, laryngopharynx, or infratemporal fossa
T4	Osseous (skull base) or cranial nerve involvement		

TABLE 2: Results of T-Staging by CT

American Joint Committee Classification			Ho's Classification		
	No. of Patients	%		No. of Patients	%
T1	17	28	T1	14	23
T2	12	20	T2	15	25
T3	3	5	T3a	5	8
T4	28	47	T3b	25	42
			T3c	–	–
Total	60	100	T3d	1	2
			Total	60	100

TABLE 3: CT Findings of Nasopharyngeal Carcinoma Infiltration

			No. of Patients	%
A.	Involvement of pharyngeal mucosal space		60	100
	• Blunting of fossa of Rosenmuller	60		
	• Thickening of levator veli palatini	55		
B.	Involvement of parapharyngeal space		39	65
	• Parapharyngeal space obliterated	33		
	• Parapharyngeal space displaced	7		
	Involvement of masticator space		9	15
	• Infiltration of infratemporal fossa	7		
	• Infiltration of pterygopalatine fossa	1		
	• Destruction of pterygoid plates	7		
	Involvement of parotid space		1	2
	Involvement of carotid space		14	23
	• Styloid process displaced	5		
C.	Involvement of retropharyngeal space		24	40
	Involvement of prevertebral space		9	15
D.	Evidence of superior intracranial spread		29	48
	• Involvement of cavernous sinus, parasellar area	14		
	• Destruction of base of skull	20		
E.	Evidence of inferior spread		6	10
	• Disease deep to tonsillar pillars	3		
F.	Anterior spread to nasal cavity (beyond posterior choanal orifice)		1	2

The posterior compartment of the nasopharynx contains the retropharyngeal space and prevertebral space. The retropharyngeal space is the most anterior of the fascia-enclosed spaces of the posterior compartment and is formed anteriorly by the buccopharyngeal fascia and posteriorly by the prevertebral fascia. Posterior spread of disease to this space was identified by the presence of a soft-tissue density tumor mass in the midline and anterior to the prevertebral muscles. More posterior spread to the prevertebral space was identified by presence of tumor in the prevertebral muscles and in the midline.

Discussion

NPC has its highest incidence (20 to 30 per 100,000 per year in males) in the southern provinces of China and in emigrant Chinese populations in Southeast Asia, Hong Kong, and elsewhere. In Singapore, with its predominantly Chinese population, this neoplasm is commonly encountered [8].

CT is well established as the most reliable method of staging and assessing the extent of NPC, since CT allows more precise staging than is possible clinically [1]. It cannot only demonstrate tumor, which may be entirely submucosal in location, but also allows assessment of areas not easily assessible clinically, such as the parapharyngeal and retropharyngeal areas [9].

The findings on CT of NPC have been previously described [1, 4, 10], but these findings do not appear to be well documented in many large series of patients. The CT appearances of the 60 patients with NPC reviewed here confirmed most of the previous findings.

NPC arises most often posterosuperiorly in the postnasal space in the region of the fossa of Rosenmuller. NPC may be entirely submucosal in site and in its early stages when it has not infiltrated through the pharyngobasilar fascia. The earliest sign on CT is usually asymmetry of the fossa of Rosenmuller with blunting of the fossa. In the patients reviewed here this finding was present in all patients, confirming that NPC originates in this region of the pharyngeal mucosal space.

NPC has a tendency for deep infiltration, and this can occur by direct extension of disease through the tough pharyngobasilar fascia or by tumor extending through the sinus of Morgagni, a gap in the superior margin of the pharyngobasilar fascia. The eustachian tube passes through this defect. Once through this fascia with tumor in the parapharyngeal space, disease spread can occur anteriorly, laterally, or superiorly. Superior intracranial spread of disease to the skull base and middle cranial fossa, which was the most common site of deep infiltration seen in this series of patients, can occur by direct extension through the skull base. Perivascular or perineural spread through the foramen lacerum and foramen ovale into the cavernous sinus area is, however, more commonly seen. Recently, MR has allowed inference of specific routes through which NPC extends from the nasopharynx to the middle cranial fossa [11]. It was suggested that extension of disease to the middle cranial fossa occurred most commonly along the eustachian tube, following it to the foramen lacerum and ovale and then into the cavernous sinus. Less commonly, tumor may extend into the middle cranial fossa via the pterygoid canal or sphenopalatine foramen. With CT it is not possible to ascertain whether tumor is infiltrating along the eustachian tube through the sinus of Morgagni or directly through the pharyngobasilar fascia. Among the patients reviewed here, in whom there was evidence of cavernous sinus and middle cranial fossa disease, associated infiltration of the pterygoid plates and pterygopalatine fossa was an uncommon finding, and disease spread to the cavernous sinus was seen most commonly after there was involvement of the foramen lacerum and foramen ovale.

Intracranial extension of NPC is best identified by the presence of infiltration of the cavernous sinus and destruction of the bony skull base. Opacification of the sphenoid sinus or the presence of a fluid level is common and can occur from concomitant inflammatory sinusitis or from decreased mucus drainage from an obstructed nasopharyngeal airway, but early direct superior extension of tumor should be looked for. Coronal scans are mandatory and can usually document bony destruction of the sphenoid sinus, which can indicate the need for a change of T-staging of the disease [6].

Direct anterolateral spread of tumor to the masticator space was present in 15% of the patients. The nasopharyngeal component of masticator space contains the infratemporal fossa and the pterygoid plates and pterygopalatine fossa. Infiltration of the latter has been shown to be one of the routes by which NPC high in the nasopharynx can infiltrate into the middle cranial fossa through the sphenopalatine fossa [11]. Direct lateral extension of disease to the parotid space from the parapharyngeal space is a rare finding in NPC and was seen in only one of the patients in this series.

Direct invasion of NPC into the retropharyngeal space is identified by the presence of a mass anterior to the prevertebral muscles. As the medial retropharyngeal nodes are medial to the carotid sheath, it was often difficult to distinguish lymph node involvement here from direct extension of tumor. The tissue planes of the retropharyngeal space are not normally as distinct as the others so that its involvement may be manifested only by asymmetric thickening of the posterior wall of the nasopharynx. Direct tumor invasion into the carotid space formed by the carotid sheath was also often difficult to distinguish from enlargement of the deep cervical nodes. Displacement of the styloid process posterolaterally may indicate direct extension of tumor from the nasopharynx, since enlarged nodes alone tend to displace the styloid process anterolaterally [7]. MR is superior to CT in the detection of carotid sheath adenopathy [12]. Adenopathy has homogeneous low signal intensity on T1-weighted images and can have a high signal intensity on T2-weighted images if necrosis is present.

T-staging of NPC by CT is widely recognized as being superior to clinical evaluation [3]. CT has been shown to upstage 55% of clinical T2 NPC lesions and 36% of clinical T3 lesions [9]. Tumor, node, metastasis (TNM) staging of NPC can be by several methods: the International Union Against Cancer (UICC) Classification system, the American Joint Committee for Cancer (AJCC) system, and Ho's classification, although the T-staging of the UICC and AJCC is now the same [5]. In the Far East, where the bulk of the disease experience lies, Ho's classification tends to be more popular. This may be because it subclassifies the tumors with bone destruction according to the site of involvement and hence influences the size of the radiation portal used for treatment [3]. Currently, there is no international agreement of the best staging system, and to allow comparison of treatment experience between different centers it has been recommended that each patient have simultaneous recording of the AJCC and Ho's staging systems [13].

As already described, the earliest sign on CT of NPC is asymmetry of the fossa of Rosenmuller with blunting of the fossa. However, the fossa of Rosenmuller is of variable size, and asymmetry of the fossa can occur normally. Hypertrophied and normal lymphoid tissue is not uncommonly seen in the nasopharynx and can fill the fossa, resulting in blunting of the fossa. If there is doubt as to whether the asymmetric blunting of the fossa is benign or pathologic, certain additional features may help in the differentiation. Physiologic measures, such as opening the mouth widely, can be used to distend the airways, as there is often variation in the distension of the fossa from side to side in NPC [14]. IV contrast medium may also be used to help distinguish adenoid tissue from tumor tissue, as with adenoid tissue the capillary bed adjacent to the pharyngobasilar fascia may enhance after contrast in a gull-wing type pattern [15]. It has also been stated that the mass effect of the adenoids should always be limited to the mucosa and submucosa and that if the deep planes are intact, then the process is most likely a benign one and limited to the mucosa [15]. As NPC has a tendency for deep infiltration, one should look for associated submucosal tumor infiltration of the adjacent deglutitional muscle, usually identified as thickening or enlargement of the levator veli palatini muscle, as well as for involvement of the parapharyngeal fat space [10]. If there is still doubt then coronal scans should be obtained.

However, the diagnosis of NPC by axial CT can be difficult if there is early disease that is limited to the submucosal area with bilateral blunting or obliteration of the fossa and no evidence of associated deep infiltration into the parapharyngeal space. In the three patients described, the only apparent other abnormality was the widened preoccipital soft-tissue width. The soft-tissue thickness of this area has been previously measured on axial scans, with the mean thickness at a scanning angle of 0° to Reid's baseline, being 6 mm in normal patients and up to 12 mm, with scan angulation of 25° [16]. Scans angled 20° or more off Reid's baseline do not apparently cause significant thickening of the soft-tissue space [14]. Our scans were done parallel to the hard palate, which is approximately 10° off Reid's baseline. The importance and significance of a widened POS width has not been emphasized in most previous reports of the CT appearances of NPC, most likely because there is usually evidence of deep infiltration of disease [2, 4, 10].

On axial CT scans of the nasopharynx, the various components and spaces of this POS area are often difficult to differentiate because there is no reliable fat plane in this region. Even with high-resolution scans, the prevertebral muscles are often the only structures that can be reliably identified, and even then these muscles may not always be easily seen. The increase in POS width in the three patients described is most likely due to the presence of tumor in the pharyngeal mucosal space, which originated in one fossa and extended submucosally across the midline to the contralateral fossa without having yet infiltrated through the pharyngobasilar fascia. The disease spread in these patients would appear to be atypical, since the normal vector of spread of disease originating from the pharyngeal mucosal space is from medial to lateral with a tendency to displace the parapharyngeal space and styloid process posterolaterally [7].

In addition, the CT density of adenoidal tissue is similar to muscle, making it difficult to differentiate from surrounding superficial nasopharyngeal musculature. On T2-weighted axial MR scans, adenoidal tissue has high signal intensity and can be clearly separated and identified by a sharp interface with the prevertebral muscles. The difficulty with CT in differentiating tumor infiltration from the prevertebral muscles can be resolved with MR imaging. MR provides improved contrast between muscles and tumor tissue. In general, where MR is available it has replaced CT as the examination of choice in the nasopharynx.

ACKNOWLEDGMENT

The author thanks Claire Lim for secretarial assistance.

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