PREOPERATIVE CT SCAN TO PREDICT ORBITAL INVASION BY PARANASAL SINUS CANCER

Pipat CHIEWVIT,[1] PHAWIN KESKOOL,[2] Kanograt PORNPANICH,[3] Kullathorn THEPHAMONGKHOL[1]

INTRODUCTION

Paranasal sinus (PNS) cancers are relatively uncommon. They present late in their course of disease nature, often with extensive disease. The standard treatment of PNS cancer is surgical resection. Extension to the orbit has an impact on patient prognosis and the surgical approach of these tumors. If orbital invasion is suspected, the surgeon and the patient are confronted with the difficult decision of orbital exenteration. Orbital exenterention is required for complete tumor resection but can be emotionally traumatic for patients and bring major change in their life. The difficult decision regarding the eye cannot be made on the basis of ophthalmic symptoms alone. Most surgeons (otolaryngologist) at our institute uses computerized tomography (CT scan) for preoperative evaluation for cancer extension including orbital invasion. Basically, if CT imaging found the mass from sinuses continuity and/or breaking bony orbit, the diagnosis of orbital invasion was not difficult. In cases in which the clinical examination and imaging are unclear, preoperative patient counseling regarding the eye is complex. A more accurate assessment of orbital invasion preoperatively would benefit both the surgeon and the patient. In addition, accurate preoperative assessment is mandatory for surgical planning. Most surgeons use the relationship between the tumor and the periorbital areas to determine whether orbital exenteration is necessary or not. Tumor invasion through the periorbital areas may warrant exenteration, whereas intact periorbital areas typically warrants preservation. When tumor abuts the periorbital areas however, assessing periorbital invasion may be difficult.

OBJECTIVE

The purpose of this study was to determine whether preoperative CT scan could offer an accurate assessment of cancer extension to the orbit. Involvement of the orbital fat manifested as soft tissue stranding in the fat is the current imaging criterion suggestive of neoplastic invasion. However, the accuracy of this criteria to predict invasion into the orbit is poorly studied. In this study we establish various criterias for predicting orbital invasion, then evaluate the accuracy of the CT scan criterias in predicting cancer invasion to the orbit.

MATERIALS AND METHODS

A retrospective study was performed involving all patients who were diagnosed paranasal sinus cancer at Siriraj hospital, by ICD 10 coding C31, from January 1995 to December 2004. Patients were undergone major operations with curative intent such as maxillectomy, ethmoidectomy or wide excision. By these criterias, there were 34 patients (23 male and 11 female) included in this study.

Of those patients, preoperative CT scans of the paranasal sinuses and operative records were re-

[1] Department of Radiology,
[2] Otolaryngology and
[3] Ophthalomology, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok 10700, Thailand.

quested to diagnose periorbital invasion. Patients were excluded from the study if preoperative CT scan and operative record were not available or operative record was not adequate for assessing periorbital involvement. By these exclusion criterias, patients during the year 1995 to 2001 were excluded because of unavailable CT scan.

Finally, there were 9 patients (6 male, 3 female) with 10 operations between 2002 to 2004 were included in this study. Note that a male patient was performed 2 operations in 2 different episodes.

Nine CT criterias for early diagnosed tumor invasion to orbit were used to assess each patient. Two criterias were the tumor's relationship to the periorbital areas i.e. tumor adjacent to the periorbital[1] and periorbita displacement.[2] One was for extraconal fat invasion, characterized by soft tissue stranding or infiltration within the extraconal fat contiguous with the primary tumor.[3] Four criterias were corresponded to extraocular muscle (EOM) i.e. EOM displacement,[4] EOM enhancement as compared with other normal EOM,[5] EOM enlargement[6] and EOM abnormal density.[7] The two other criterias were nodular tumor interface with orbit[8] and lytic bone.[9]

One consultant neuroradiologist interpreted CT scan following the mentioned 9 items as either positive or negative without intraoperative informations.

Gold standard of positive periorbital involvement is it's involvement seen intraoperatively Data analyses were done by describtive method because of small population.

EOM = Extra Ocular muscle

RESULTS

During January1995 to December 2001, there were 4 positive surgically confirmed cases of orbital invasion by paranasal sinus cancers without preoperative CT scan available because our hospital, during that time, did not collect any film of patient with no follow up more than 5 years or they are lost because of other reasons. So only 10 operations of 9 patients during 2002 to 2004 were included in this study. Note that one patient were done 2 operations at two different times.

Table 1 Patients of paranasal sinus cancer who were undergone operation between 1995-2004.

year	n	male	female	Periorbital invasion
1995	3	2	1	1
1996	4	2	2	1
1997	10	7	3	1
1998	-	-	-	-
1999	3	3	0	1
2000	3	1	2	0
2001	1	1	0	0
2002	5	3	2	1
2003	4	3	1	0
2004	1	1	0	0
total	**34**	**23**	**11**	**5**

Of the included 10 operations, there was only one patient (patient no.3) who had intraoperatively proven orbital invasion by paranasal sinus cancer. This case had frontal sinus carcinoma with intraoperatively comfirmed tumor invasion through the periorbital to the right orbit. This case is the only one that orbital exenteration was done.

Table 2 The results of CT scan interpretation criterias for orbital invasion by paranasal sinus cancer in 10 patients during 2002-2004.

Patient No.	**No. 1**	**No 2**	**No. 3**	**No. 4**	**No. 5**	**No. 6**	**No. 7**	**No. 8**	**No. 9**	**No. 10**
1.Tumor adjacent to the periorbital	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2.Periorbital displaced	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
3.Extraconal fat involvement	Y	Y	Y	Y	N	Y	N	Y	N	N
4.EOM displaced	N	Y	Y	Y	N	Y	N	N	N	N
5.EOM abnormally enhanced	N	Y	Y	Y	N	N	N	Y	N	N
6.EOM enlarged	N	N	Y	Y	N	N	N	N	N	N
7.EOM abnormal density	N	Y	Y	Y	N	N	N	N	N	N
8.Nodular tumor interface with orbit	Y	Y	Y	Y	N	Y	N	Y	N	Y
9.Lytic bone	Y	Y	Y	Y	Y	Y	Y	Y	N	Y

Y = yes or positive, N = no or negative EOM = Extra Ocular Muscle

Pathological reports of cancer cell types could be found in 32 of 34 cases during the entire length of study between 1995 to 2004. No pathological or surgical report was found in two cases. Squamous cell carcinoma is the most frequent cancer cell type, demonstrated in 20 of 32 cases.

Adenoidcystic carcinoma and undifferentiated carcinoma were the second most common in this study, both were shown by 4 from 20 cases. Only one case for each was found, i.e. neuroendocrine tumor, malignant fibrous histiocytoma, squamous hyperplasia and adenocarcinoma.

The paranasal sinuses, most frequently involved by cancer in this study, of the 34 cases, 32 cases were maxillary sinuses and the other two, each one for ethmoid and frontal sinuses. If considering only pathological available cases, thirty are of maxillary sinuses and each one for ethmoid and frontal sinus.

Among 32 maxillary sinus cancer, the most common cell type is squamous cell carcinoma found in 19 cases, adenoidcystic carcinoma in 4 cases, undifferentiated carcinoma in 3 cases and each one for neuroendocrine tumor, malignant fibrous histiocytoma, squamous hyperplasia and adenocarcinoma.

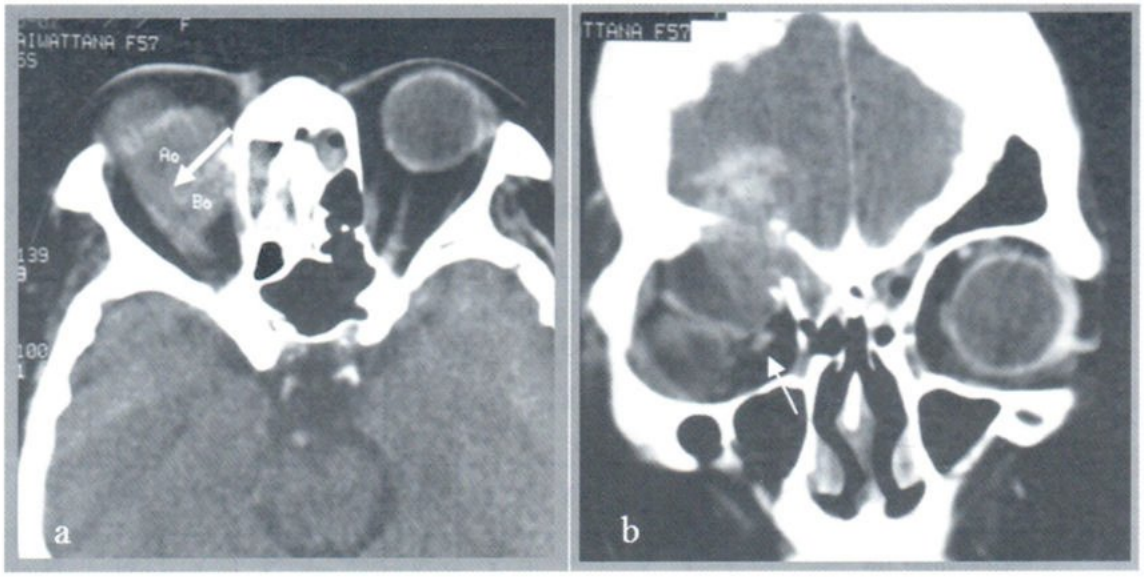

Fig.1 Patient no.3 who had right frontal sinus squamous cell carcinoma with intraoperatively confirmed periorbital invasion. Axial scan (a) shows medial rectus displacement (thick arrow). Coronal scan (b) shows bony destruction at the roof and superomedial right orbit, medial rectus enlargement (thin arrow) and inferolaterally displaced eye ball.

Patient no.3 was the only one who had operatively confirmed periorbital rupture indicating orbital invasion. This case was positive in every criterias especially extraocular muscle enlargement (see figure 1).

Extraocular muscle enlargement is the criteria that is least interpreted positive. Only 2 cases (patient no.3 and 4) were positive by this criteria.

Fig.2 Patient no.1 who had right maxillary sinus squamous cell carcinoma with intraoperatively confirmed intact periorbital. Coronal scan (a) shows periorbital displacement (arrow). Picture b shows bony dehiscence (arrow head). This patient was lack of EOM criterias.

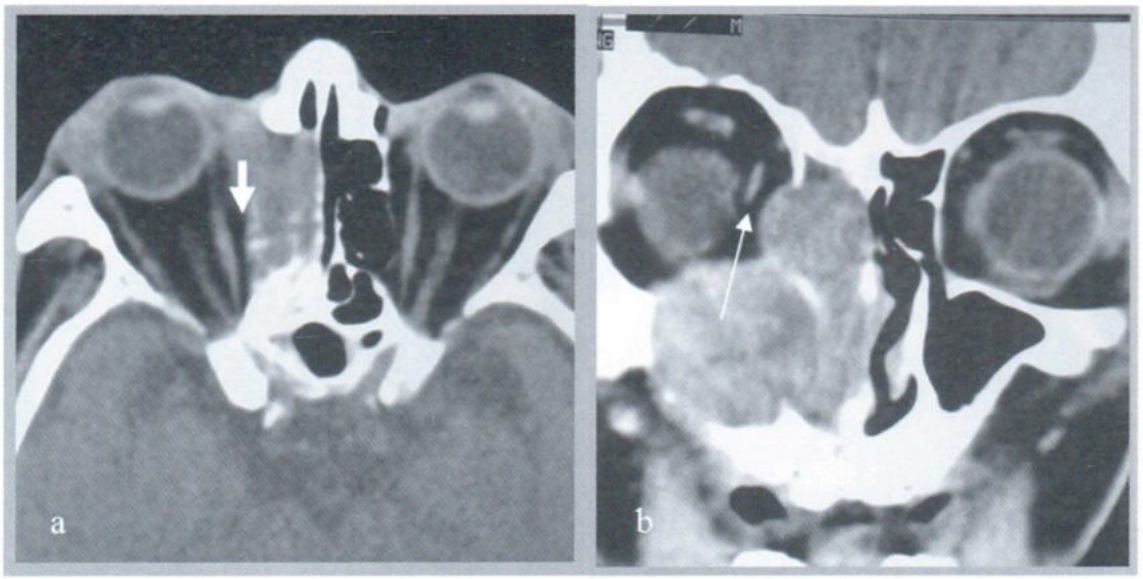

Fig.3 Patient no.2 who had squamous cell carcinoma of the right maxillary sinus with positive in all criterias except extraocular muscle enlargement. Axial scan (a) shows periorbital bow laterally and extraconal fat involvement (thick arrow) but lack of extraconal muscle enlargement. Coronal scan (b) shows lytic bony orbit inferiorly and medially and extraocular muscle displacement (thin arrow). This patient showed intact periorbital intraoperatively.

Fig.4 Patient no.4 who had right maxillary sinus squamous cell carcinoma. This patient's scan were interpreted positive in all criterias but intraoperation showed intact periorbital.

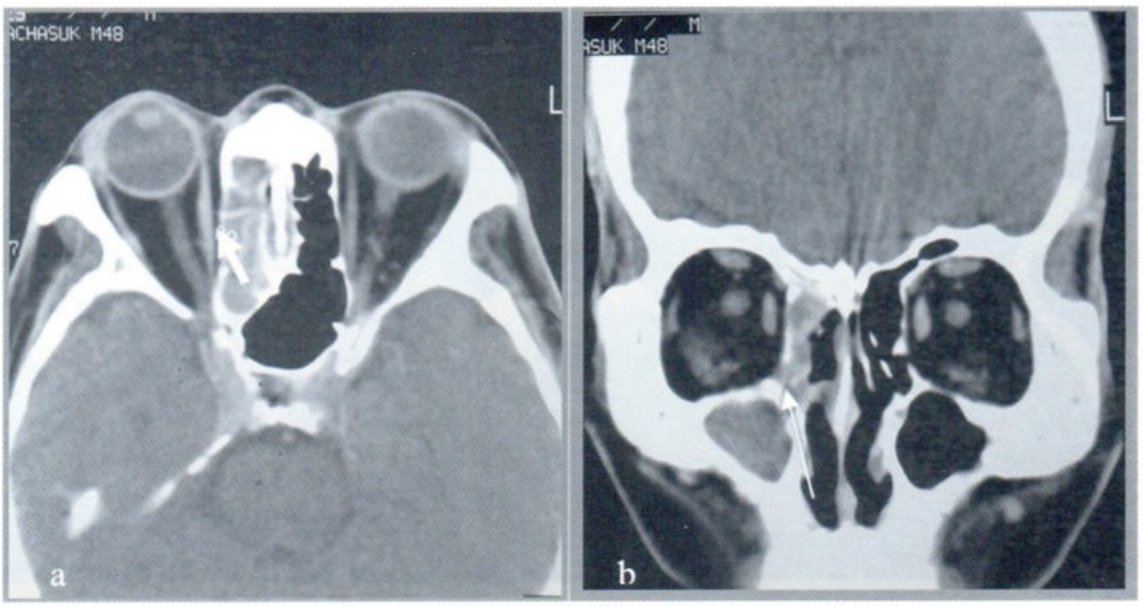

Fig.5 Patient no.5 who had right maxillary squamous cell carcinoma with intact periorbital seen intraoperatively. Axial scan (a) shows tumor adjacent to the periorbital and periorbital displacement (thick arrow). Coronal scan (b) shows tumor mass in right maxillary sinus and bony dehiscence (thin arrow).

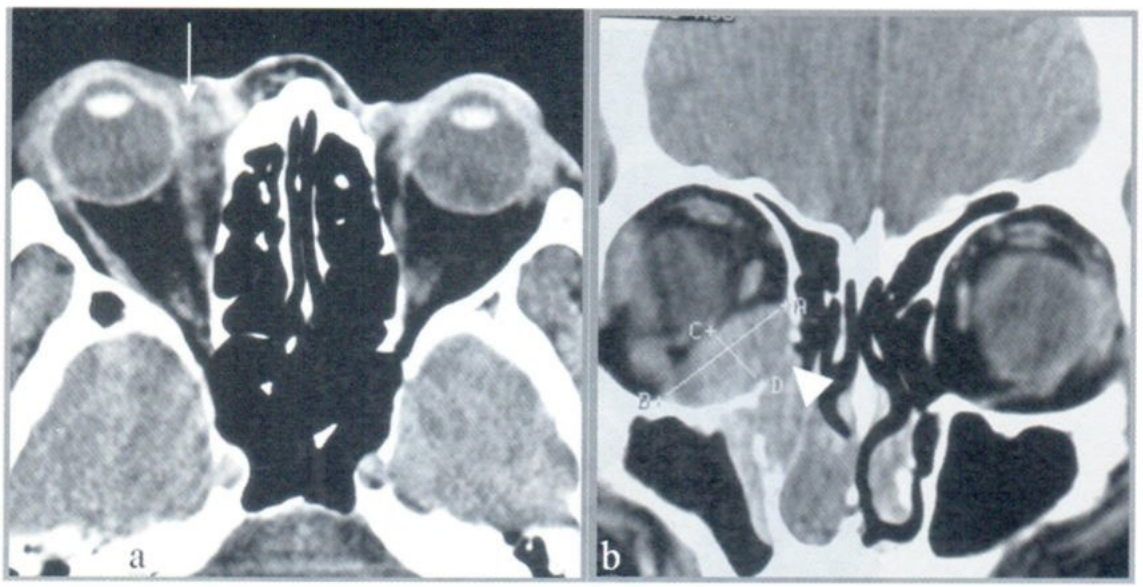

Fig.6 Patient no.6 who had right maxillary undifferentiated carcinoma. Axial scan showed tumor mass adjacent to periorbita (arrow). Coronal scan (b) shows bony orbit inferomedially dehiscence, periorbita bowed laterally and extraconal muscle displacement (arrow head). This patient showed intact periorbital intraoperatively.

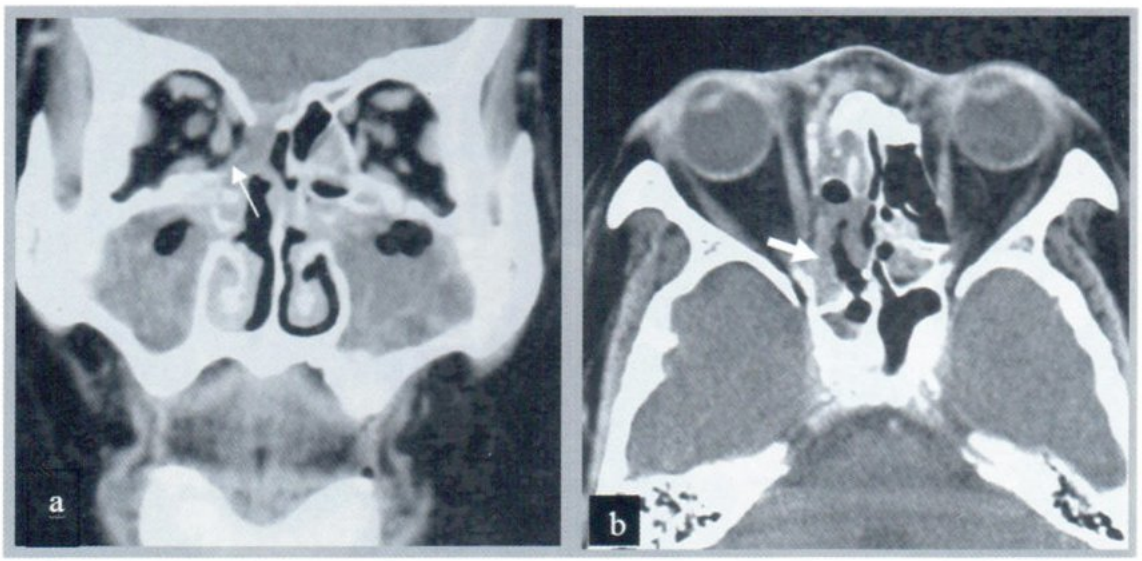

Fig.7 Patient no.7 who had right ethmoid and frontal squamous cell carcinoma. Coronal scan (a) shows periorbita displacement and bony dehiscence (thin arrow). Axial scan (b) shows tumor mass in right ethmoid sinus with bony dehiscence (thick arrow). This patient was lack of EOM displacement, enhancement, enlargement or abnormal density.

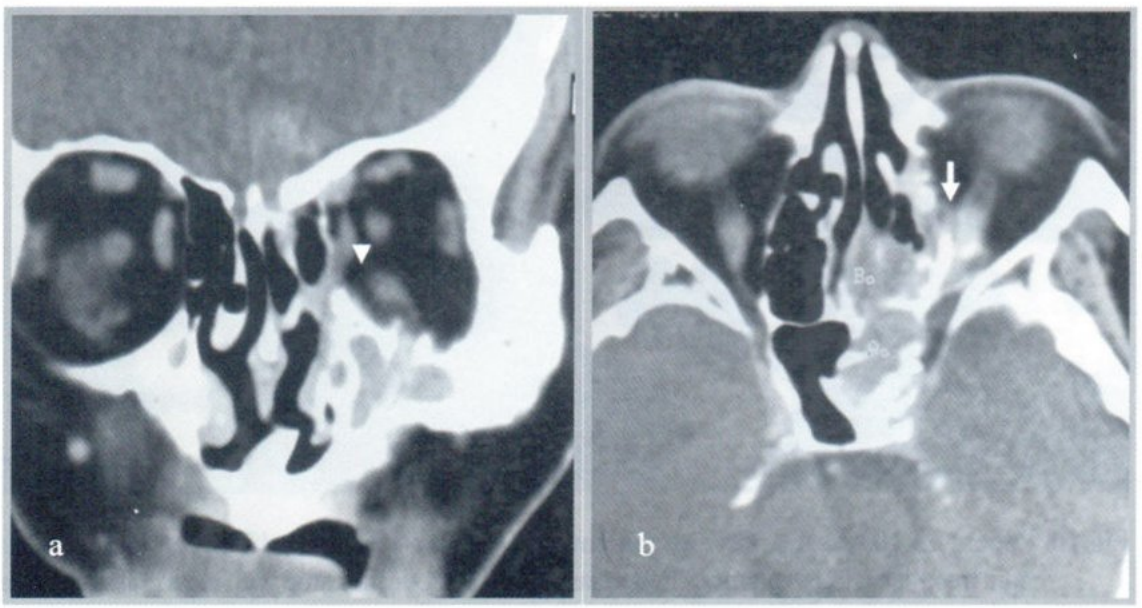

Fig.8 Patient no.8 who had left ethmoid squamous cell carcinoma with intact periorbita shown intraoperatively. Coronal scan (a) shows left medial rectus muscle displacement (arrow head). Axial scan (b) shows bony dehiscence and extraconal fat involvement (arrow).

Fig.9 Patient no.9 who had squamous hyperplasia of right maxillary sinus with intact periorbital seen intraoperatively. There was only tumor adjacent to periorbita (arrow) shown in picture a. The remaining 8 criterias were interpreted negative.

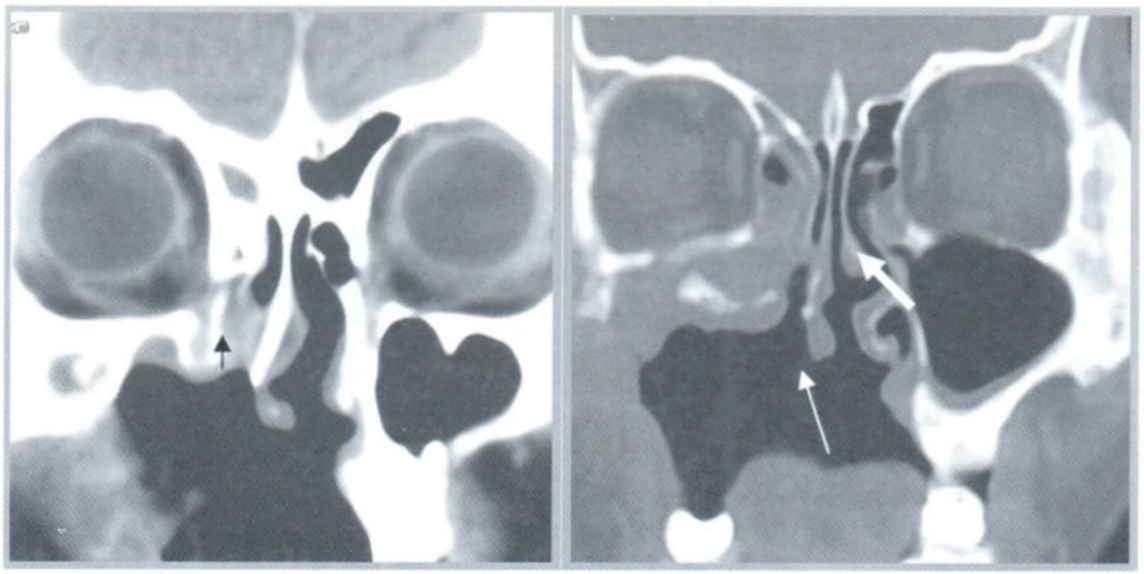

Fig.10 Patient no.10 was the previous patient no.9 who was performed Denker operation for right maxillary sinus squamous hyperplasia. This episode, he came with recurrent squamous cell carcinoma. Both picture a and b shows bony defecs from previous operation. There were periorbital displacement (thin arrow) shown in picture a. and bony dehiscence (thick arrow) shown in picture b.

DISCUSSION

Paranasal sinus tumors, especially cancers, are relatively rare and tend to have an indolent course. Therefore, they are usually diagnosed at advanced stages. In most patients diagnosed with sinonasal carcinoma, the cause is unclear. Several types of nasal cavity and paranasal sinus cancer are relatively more

common in individuals engaged in certained occupations or exposed in certain chemical compounds. Adenocarcinoma of the nasal cavity and ehthmoid sinus, for instance, occurs more often in carpenters and sawmill workers who are exposed to wood dust, and squamous cell carcinoma of the nasal cavity develops more often in nickel workers. Maxillary sinus carcinoma was associated with thorium oxide (thorotrast recipient), a radioactive thorium-containing contrast material used for radiographic study of the maxillary sinuses.[6,7,8] Occupational exposure in the production of chromium, mustard gas, isopropyl alcohol, or radium also increase the risk of sinonasal carcinoma.

Maxillary sinus cancer is the most extensive and the highest prevalence among paranasal sinus cancer. The incidence ratio between male and female is about 2:1. When early in the disease or small, it is usually misdiagnosed as chronic sinusitis, nasal polyp, lacrimal duct obstruction or cranial arteritis.

The presenting symptoms, at M.D. Anderson Cancer Center between 1969-1985 among 73 patients, are face swelling/ pain/ paresthesia of cheek,[26] nasal symptom e.g.epistaxis and nasal discharge,[20] oral symptom e.g.ill-fitting denture and palatal mass[19] and eye symptom e.g.proptosis and diplopia.[5,9]

The diagnoses were done by history taking and physical examination. The history taking must be comprised of risk factor for cancer, too. Physical examination must include nasal and oral cavities, palpation of the cheek, evaluation of eye movement and function, cranial nerve examination. Imagings are begun with plain film of the paranasal sinus. This film provides haziness of paranasal sinus and bony destruction. CT or MRI are always accompanied for further visualization of extension and operative treatment planning. At our institution, MRI is rarely done because CT scan usually gives adequate information of bony destruction and extension of pathology for operative treatment planning.

Orbital invasion has very importance in the course of disease. Nowadays according to the surgical view point, orbital invasion is characterized by tumor invading through periorbita into orbital content. Orbital exenteration is usually done, if there is orbital invasion, for complete treatment or curative intent.

Orbit is a cone-shape space comprised of 7 bones i.e. the frontal, greater and lesser wings of the sphenoid, the zygoma, the maxilla, the lacrimal and the ethmoid. The condensed periosteum of these bones makes up "periorbital" which is continuous with dura mater at the optic foramen and superior orbital fissure. Because of it's strength and durability, it is considered an effective barrier to tumor extension to the orbit.

The periorbita itself is very thin to be visualized by CT or MRI. Because of it's strength, durability and elasticity, it may be still intact even cancer protrude deep into the orbit. When we see tumor extends into orbit alone, it may or may not cause periorbital rupture. There is still no definite CT scan criteria to predict cancer invading through periorbita. Currently we use the CT finding as orbital fat stranding to predict orbital invasion. Due to these problems, we tried to establish other reliable criterias for more accurate prediction.

The study by Eisen et.al.[5] revealed that CT scan had more accuracy in predicting orbital invasion than MRI because of the ability to assess fat and bone better. They found that the criteria "adjacent to periorbital " was the most sensitive (90%) and the criteria "extraocular muscle enlargement" was the most specific (94%). They also found that the "extraconal fat involvement", the widely used criteria, strongly predicting orbital invasion but lack of extraconal fat involvement cannot rule out invasion.

The information by Byron J.Bailey[5] reveals that MRI had much more accuracy than CT acan in predicting orbital invasion by paranasal sinus cancer. The reason was that CT scan could not distinguish tumor adjacent to periorbital from real invasion. Operative reassurement must be done in every case.

In our study we had the limitations due to retrospective study, too small study population and furthermore there is only one case which was

intraoperatively proven as positive for periorbital invasion. Among the set up criterias, we compare the different findings found in positive case (case no.3) to negative cases, we notified that this case is the only one in 2 cases that had "extraocular muscle enlargement" and also only this case that all 9 criterias are positive. The "extraocular muscle enlargement" criteria of CT scan interpretion may be a good predictor for orbital invasion by paranal sinus cancer. This was hypothesized that the tumor has directly invaded passing through the bony orbital wall and also the extraconal fat until involving the conal muscles. Therefore, it is implied that the periorbital must already had been invaded. By concerning the sign of "extraocular muscle enlargement" which is not the pathognomonic sign for this specific disease, we strongly recommended using only the muscles that has proximity to the tumor and to use in adjunction with the other criterias.

However, the other case (case no.4) that shared this positive sign but intraoperatively an intact periorbital was found, this may be due to the tumor density is isodense to the extraocular muscle and may be overestimated size have been involved. By concerning of this issue, we suggest that MRI orbit with fat suppression with gadolinium contrast agent could be the next or the most proper investigation in the analysis of extraocular muscle invasion.

The conclusion of the sinus involvement and cell type of cancer were not surprising. The maxillary sinus is the most frequently involved sinus, 32 from 34 cases. The squamous cell carcinoma is the most common cell type, seen in 19 from 32 pathological proven cases, followed by adenoidcystic carcinoma, 4 of 32 and undifferentiated carcinomas were demonstrated in 3 of 32 cases. These cell type findings are similar to widely known information such as from Byron J. Bailey's information.

CONCLUSION

CT scan may aid in screening, staging and counseling patients about surgical planning and prognosis of paranasal sinus cancer. Even though, CT scan is not sufficiently accurate to substitute intraoperative assessment of periorbital invasion, CT orbital scan, using the sign of "extraocular muscle invasion or enlargement", may be a good predictor for periorbital invasion by paranasal cancer. In case of CT scan has an equivocal in the evaluation of extraocular muscle invasion or enlargement, we recommend that MRI with fat suppression technique would be the next investigation.

REFERENCES

1. Byron J. Bailey; Neoplasm of the Nose and Paranasal Sinuses. *Head and Neck Surgery.* Philadelphia; 1993: 1091-1117
2. Peter M. Som and Hugh D. Curtin; tumor and tumor-like conditions, sinonasal cavity. *Head and Neck Imaging.* Mosby; 2003: 261-373
3. Jame D.Cox and K.Kian Ang; The nasal fossa and Paranasal Sinuses. *Radiation Oncology.* Mosby; 2003: 160-176
4. Jatin P. Shah; Nasal cavity and paranasal sinuses. Head and Neck Surgery. Mosby wolfe; 1996: 49-83
5. Marc D Eisen, David M. Yousem; Preoperative imaging to predict orbital invasion by tumor; Head & Neck August 2000; 456-462
6. Torjussen W, Solberg LA, Hgetviet AC. Histopathological changes of nasal mucosa in nickel workers: a pilot study. Cancer 1979; 44: 963-974.
7. Acheson ED, Hadfield EH, Macbeth RG. Carcinoma of the nasal cavity and accessory sinuses in woodworkers. Lancet 1967; 1: 311-312.
8. Acheson ED, Cowdell RH, Hadfield E, et al. Nasal cancer in wood workers in the furniture industry. Br Med J 1968; 2: 587-596.
9. Jiang GL, Ang KK, Peters LJ, et al. Maxillary sinus carcinomas: natural history and results of postoperative radiotherapy. Radiother Oncol 1991; 21: 193-200.