Journal of Hard Tissue Biology 34[1] (2025) 35-40

CODEN-JHTBFF, ISSN 1341-7649

Original

Evaluation of CT Findings in Squamous and Non-Squamous Cell Carcinomas of the Maxillary Sinus

Yuka Asaumi[1,2)], Mamiko Fujikura[3)], Miki Hisatomi[3)], Wlla E. Al-Hammad[1,4)], Yohei Takeshita[5)], Shunsuke Okada[3)], Toshiyuki Kawazu[5)], Yoshinobu Yanagi[6)] and Junichi Asaumi[1,3,5)]

[1)] *Department of Oral and Maxillofacial Radiology, Graduate School of Medicine, Dentistry and Pharmaceutical Sciences, Okayama University, Okayama, Japan*
[2)] *Tai Orthodontic Office, Okayama, Japan*
[3)] *Department of Oral and Maxillofacial Radiology, Okayama University Hospital, Okayama, Japan*
[4)] *Department of Oral Medicine and Oral Surgery, Faculty of Dentistry, Jordan University of Science and Technology, Irbid, Jordan*
[5)] *Department of Oral and Maxillofacial Radiology, Faculty of Medicine, Dentistry and Pharmaceutical Sciences, Okayama University, Okayama, Japan*
[6)] *Department of Dental Informatics, Faculty of Medicine, Dentistry and Pharmaceutical Sciences, Okayama University, Okayama, Japa*
(Accepted for publication, December 4, 2024)

Abstract: The aim of the present study was to compare CT images between squamous cell carcinoma (SCC) and non-SCC found in the maxillary sinus, and to identify features that could be used to differentiate between SCC and non-SCC. Patients who visited the Faculty of Dentistry, Okayama University Hospital, between April 2007 and March 2023, underwent head and neck CT, and had tumors extending into the maxillary sinus that were diagnosed histopathologically as malignancy, were enrolled. The main seat of the mass, bony changes in the maxillary sinus wall, and extension into the surrounding area were assessed. These imaging features were evaluated according to SCC or non-SCC, and the characteristics of the two classes were assessed. Comparisons between the two groups were made using the Fisher exact probability test. There were 11 cases each of SCC and non-SCC. In 11 SCC and 7 non-SCC cases, the main seat of the mass occupied the entire maxillary sinus. The frequency of mass occupying the whole sinus was significantly higher in SCC than in non-SCC ($p<0.05$). Bone-thickening type disease was found only in squamous cell carcinoma 4/11 (36.4%), with there being a significant difference between SCC and non-SCC ($p<0.05$). Occupancy of the entire maxillary sinus by the mass and bone thickening on CT images were useful for differentiating between SCC and non-SCC arising in the maxillary sinus.

Key words: Maxillary sinus, Squamous cell carcinoma, Non-squamous cell carcinoma, CT

Introduction

The sinuses include the frontal, ethmoidal, maxillary, and sphenoid sinuses, with the maxillary sinus having the largest cavity. The maxillary sinus is pyramidal, consisting of anterior, posterior, medial, upper, and lower walls. Diseases occurring in the maxillary sinus include inflammatory, cystic, and neoplastic diseases[1)]. Sinus tumors account for less than 3% of all head and neck malignancies, but maxillary sinus cancer accounts for approximately 80% of all sinus cancers[2)]. Squamous cell carcinoma (SCC) is the most common malignant tumor arising in the maxillary sinus, with a frequency of approximately 80%, followed by adenocarcinoma, lymphoma, and adenoid cystic carcinoma[3,4)]. Imaging is important for diagnosing these malignant tumors, and computed tomography (CT) and magnetic resonance imaging (MRI) allow three-dimensional imaging of these lesions. CT allows diagnosis of both hard and soft tissues, with the ability to visualize complex structures in a continuous cross-sectional view, allowing the destruction and deformation of the maxillary sinus wall to be understood three-dimensionally. As well as excellent visualization of bone, CT also facilitates observation of soft tissue lesions that have developed in or around the maxillary sinus. For this reason, we decided to use CT for imaging in this study. The common treatment options for maxillary sinus cancer are surgical resection, radiotherapy, and chemotherapy[5)], but SCC and non-SCCs can be treated differently[6)], and differentiation between the two is important for selecting the appropriate treatment option. Therefore, the aim of this study was to compare the CT findings of SCC and non-SCCs in the maxillary sinus and determine those features of use for differentiating between them.

Correspondence to: Dr. Mamiko Fujikura, Department of Oral and Maxillofacial Radiology, Okayama University Hospital, 2-5-1 Shikata-cho, Kitaku, Okayama, 700-8558 Japan; Tel: +81-86-235-6705; Fax: +81-86-235-6709; Email: fujikura@okayama-u.ac.jp

Materials and Methods

The inclusion criteria for selection of subjects were: patients who visited the Okayama University Hospital Dental Department between April 2007 and March 2023, underwent head and neck CT, and had a tumor in the maxillary sinus that was diagnosed as malignancy by histopathological examination. We considered 22 cases of maxillary sinus malignancy where the primary lesion was located within the maxillary sinus. This study was approved by the Ethical Review Committee of Okayama University Hospital (No. 2306-012), and informed consent was obtained through an opt-out method.

Imaging was conducted using one of five types of CT scanner: Asteion (Toshiba, Medical Systems, Tokyo, Japan), Aquilion ONE and Aquilion Precision (Canon Medical Systems, Tochigi, Japan), SOMATOM Definition Flash (Siemens Healthineers, Erlangen, Germany), and Dis-

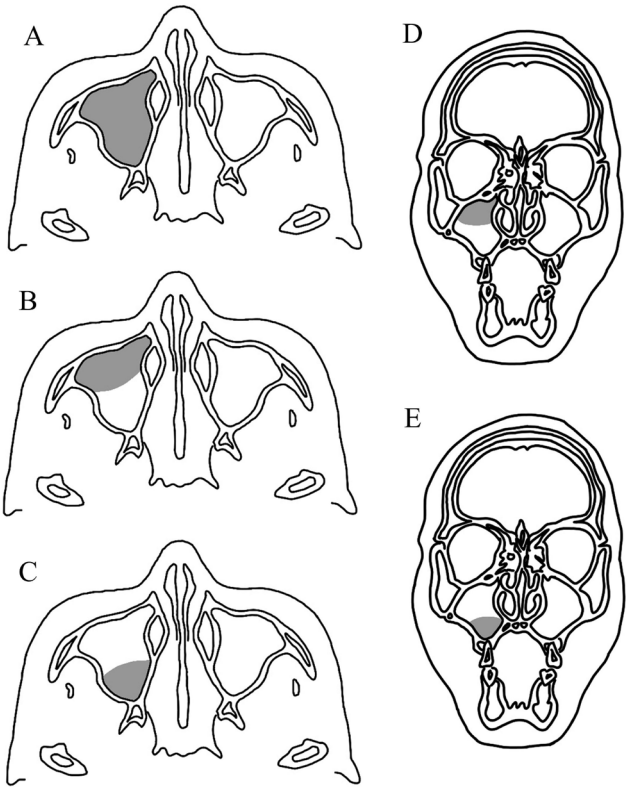

Figure 1. Grey color indicates the location of the mass. The extent of the mass was divided into one of five categories: (A) entire maxillary sinus, (B) anterior, (C) posterior, (D) superior, and (E) inferior.

covery CT750 HD (GE Healthcare, Milwaukee, WI, USA). The CT parameters included field of view from 16 × 16 to 29.6 × 18 cm, 120 kV, and 110–311 mA. CT scans were performed on all 22 patients, with contrast-enhanced CT being performed on 17.

The CT was analyzed by five radiologists with 1, 6, 10, 22, and 26 years of experience. In cases of divergent opinions among the readers, a consensus was reached through discussion. The readers assessed the following points: 1) extent of the mass, 2) bone changes in the maxillary sinus, and 3) extension into the surrounding area (nasal cavity, other sinuses, orbit). The extent of the mass was classified according to whether it occupied the whole maxillary sinus, or anterior, posterior, superior, or inferior portions (Fig. 1). Bone changes in the maxillary sinus wall were classified into four types: 'destructive,' 'expansile,' 'permeative', and 'thickened'. This is a four-category classification based on the report of Kato et al.[7], which adds a thickened type to the three types of bone changes. Destructive type was defined as no bony expansion of the adjacent maxillary sinus wall with bone destruction. Expansile type was defined as adjacent maxillary sinus wall with bony swelling due to mass. Permeative type was defined as lesions that cross the maxillary sinus wall, with the original shape of the maxillary sinus wall remaining as a linear structure within the mass without complete destruction. Thickened type was defined as increased wall thickness within the maxillary sinus, with sclerotic changes in the thickened and surrounding bone (Fig. 2). For extension into other paranasal sinuses, the presence or absence of mass extension into the frontal sinus, ethmoid sinus, and sphenoid sinus was assessed. Extension into the orbit was assessed as with or without destruction of the orbital floor, with coronal sections being used for this purpose.

The recorded imaging features were classified according to SCC and non-SCCs, and their respective characteristics were evaluated. To determine the extent of SCC and non-SCC masses, the body changes in the maxillary sinus wall and extension into the surrounding area (nasal cavity, other sinuses, and orbit) were compared. Statistical comparisons

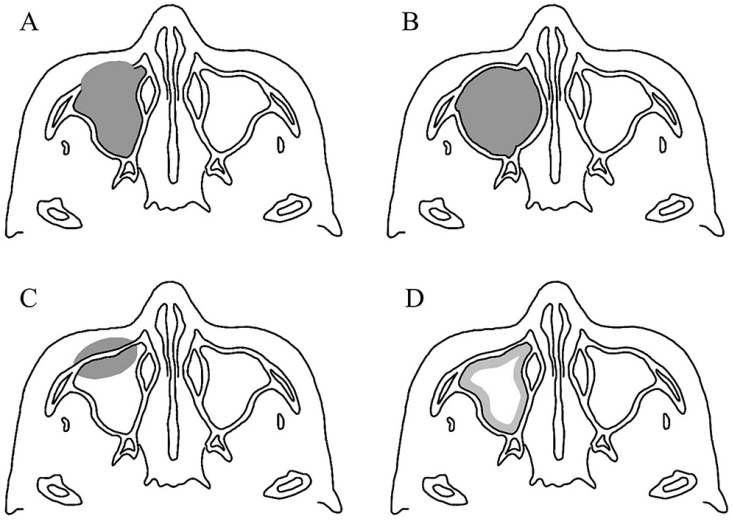

Figure 2. Bone changes in the maxillary sinus wall. (A) Destructive type: no bony expansion of the adjacent maxillary sinus wall with bone destruction. (B) Expansile type: adjacent maxillary sinus wall with bony swelling due to mass. (C) Permeative type: lesions that cross the maxillary sinus wall, with the original shape of the maxillary sinus wall remaining as a linear structure within the mass without complete destruction. (A)–(C) Dark grey area shows a mass lesion. (D) Thickened type: increased wall thickness within the maxillary sinus, with sclerotic changes in the thickened and surrounding bone. Light-grey range shows bone thickening.

Table 1. Cases

	Squamous cell carcinoma	Non-squamous cell carcinoma	Total
Number (Male : Female)	11 (9 : 2)	11 (6 : 5)	22 (15 : 7)
Age	38-87	44-91	38-91
Average	66.6	71.9	69

Table 2. Histopathological classificasion

	Squamous cell carcinoma	Non-squamous cell carcinoma	
Classification	11	Lymphoma	: 4
		Neuroendocrine carcinoma	: 2
		Adenoid cystic carcinoma	: 1
		Mucoepidermoid carcinoma	: 1
		Ameloblastic carcinoma	: 1
		Undifferentiated pleomorphic sarcoma	: 1
		Angiosarcoma	: 1
Total	11	11	

Table 3. Extent of mass

	Squamous cell carcinoma (11)	Non-squamous cell carcinoma (11)	p-value
Whole	11 (100%)	7 (63.6%)	<0.05*
Anterior	0 (0%)	2 (18.2%)*	0.238
Posterior	0 (0%)	1 (9.1%)*	0.500
Superior	0 (0%)	0 (0%)	1.000
Inferior	0 (0%)	2 (18.2%)	0.238

* One case is duplicated because of anterior and posterior extension.

Table 4. Bene change in maxillary sins

	Squamous cell carcinoma*	Non-squamous cell carcinoma*	p-value
Destructive	11/11 (100%)	10/11 (90.9%)	0.500
Expansile	3/11 (27.3%)	5/11 (45.5%)	0.330
Permeative	0/11 (0%)	3/11 (27.3%)	0.107
Thickened	4/11 (36.4%)	0/11 (0%)	<0.05*

* Duplicate notations are shown.

Table 5. Bene change in maxillary sins (non-SCC)

	Lymphoma	Neuroendocrine carcinoma	Adenoid cystic carcinoma	Mucoepidermoid carcinoma	Ameloblastic carcinoma	Undifferentiated pleomorphic sarcoma	Angiosarcoma	Total
Destructive	3/4	2/2	1/1	1/1	1/1	1/1	1/1	10/11
Expansile	1/4	1/2	0/1	1/1	1/1	0/1	1/1	5/11
Permeative	1/4	0/2	1/1	0/1	0/1	1/1	0/1	3/11
Thickened	0/4	0/2	0/1	0/1	0/1	0/1	0/1	0/11

Table 6. Extension into the surrounding area

	Squamous cell carcinoma*	Non-squamous cell carcinoma*	p-value
Nasal cavity	9/11 (81.8%)	8/11 (72.7%)	0.500
Ethmoid sinus	10/11 (90.9%)	6/11 (54.5%)	0.074
Sphenoid sinus	0/11 (0%)	1/11 (9.1%)	0.521
Frontal sinus	0/11 (0%)	0/11 (0%)	1.000
Orbit	3/11 (27.3%)	5/11 (45.5%)	0.330

* Duplicate notations are shown.

were performed using the Fisher exact probability test, with statistical significance being defined as a p-value less than 0.05. GraphPad Prism 8 (MDF Co., Ltd., Tokyo, Japan) were used to conduct statistical analysis.

Results

Fifteen men and seven women aged 38–91 years (mean 69.0 years) were included in this study. There were 11 patients with SCC (nine men and two women, aged 38–87 years (mean 66.6 years) and 11 patients

with non-SCCs (six men and five women, aged 44–91 years (mean 71.9 years) (Table 1). The histopathological classifications are given in Table 2.

Extent of the mass

The mass occupied the whole of the maxillary sinus in all 11 cases of SCC and 7 out of 11 cases of non-SCCs. The frequency of occupation of the whole sinus was significantly higher in SCC than in non-SCCs (Table 3).

Bone changes in the maxillary sinus

Destructive disease was the most common type in both SCC and non-SCCs. Ten of the 11 non-SCCs showed destructive-type disease, with only one malignant lymphoma not showing destructive-type disease. Permeative-type disease was not found in SCC, but was present in three non-SCCs. Bone thickening was found only in SCC 4/11 (36.4%), with there being a significant difference compared with non-SCCs. (Tables 4 and 5).

Extension into the surrounding area (nasal cavity, other sinuses, orbit)

Extension to the ethmoid sinus was common in both SCC and non-SCCs (Table 6).

Discussion

In the present study, we compared CT images between SCC and non-SCCs of the maxillary sinus. The number of cases with mass occupation of the entire maxillary sinus was significantly higher in SCC than in non-SCCs. SCCs occupied the entire maxillary sinus before extending outside the maxillary sinus, whereas non-SCCs may leave an air-containing cavity and extend outside the maxillary sinus. SCC is characterized by a high frequency of destructive forms, with a third of SCCs reported to have residual bone wall inside the tumor[7], which is seen as broken and fragmented punctate bone fragments. Destructive-type disease is also reported to be present in many non-SCCs, such as lymphoma, adenoid cystic carcinoma, neuroendocrine carcinoma, ameloblastic carcinoma, undifferentiated pleomorphic sarcoma, and angiosarcoma[8]. In our study, lymphomas were the only type that did not show a destructive form. As lymphomas are lesions that show a variety of bone changes[9], those that do not show a destructive form are suspected to be lymphomas. SCC with dilated bone destruction in the adjacent bone wall was reported in approximately 7% of cases[7], whereas in our study it was present in 27.3% of SCC cases. According to the literature, lesions with dilated forms are typically lymphoma[9], adenoid cystic carcinoma[8], mucoepidermoid carcinoma[10], or ameloblastic carcinoma[11], with lymphoma, mucoepidermoid carcinoma and ameloblastic carcinoma showing a dilated form in this study. We found no significant differences in the rates of dilated forms between SCC and non-SCCs, and they could not be differentiated in this respect.

In the present study, permeative-type disease was found in non-SCCs (lymphoma, adenoid cystic carcinoma, and undifferentiated pleomorphic sarcoma). It is reported that non-SCCs show a tendency to present with a permeative type[7,12], with permeative-type disease being considered to be a feature indicative of non-SCCs. Bone thickening was observed in four cases of SCC, but in contrast, it was not observed in non-SCCs. The finding of bone thickening can therefore be considered to raise suspicion of SCC. Bone thickening generally results from chronic inflammation; chronic sinusitis is reported to be involved in the development of maxillary sinus cancer and may be a risk factor[13]. In terms of surrounding extension, both SCCs and non-SCCs were found to extend into the nasal cavity, ethmoid sinus, and orbit, but rarely into the sphenoid sinus and frontal sinus. These results suggest that maxillary sinus carcinoma tends to spread to the surrounding area, but because of its anatomical location, there were few cases of sphenoidal or frontal sinus extension.

In summary, the mass extent occupied the entire maxillary sinus in all cases of SCC, with the rate of this differing significantly from that in non-SCCs ($p<0.05$*). Bony changes showing a thickened form to the maxillary sinus were found in four cases of SCC, but not in non-SCCs, with the difference being significant ($p<0.05$*).

This study is subject to limitations. The number of cases was small because it was conducted at a single center. Additionally, there were several cases of non-SCCs that were classified as one case on histopathological classification, and these may have included atypical cases.

In conclusion, our comparison of CT images of SCC and non-SCCs found in the maxillary sinus showed that occupancy of the whole of the maxillary sinus by the mass and bone thickening are useful for the differential diagnosis between SCC and non-SCCs.

Acknowledgements

We thank Edanz (https://jp.edanz.com/ac) for editing a draft of this manuscript.

Conflict of Interest

The authors declare no conflicts of interest associated with this manuscript.

References

1. Bell GW, Joshi BB and Macleod RI. Maxillary sinus disease: Diagnosis and treatment. Br Dent J 210(3): 113-118, 2011
2. Sangal NR, Lee YJ, Brady JS, Patel TD, Eloy JA, Baredes S and Park RCW. The role of elective neck dissection in the treatment of maxillary sinus squamous cell carcinoma. Laryngoscope 128(8): 1835-1841, 2018
3. Bhattacharya N. Factors affecting survival in maxillary sinus cancer. J Oral Maxillofac Surg 61(9): 1016-1021, 2003
4. Kacorzyk U, Kentnowski M, Szymczyk C, Chmielik E, Bobek-Billewicz B, Składowski K and Rutkowski T. Results of primary treatment and salvage treatment in the management of patients with non-squamous cell malignant tumors of the sinonasal region: Single institution experience. J Clin Med 12(5): 1953, 2023
5. Won HS, Chun SH, Kim B-soo, Chung SR, Yoo LR, Jung CK, Kim YS, Sun Di, Kim MS and Kang JH. Treatment outcome of maxillary sinus cancer. Rare Tumors 1(2): 110-114, 2009
6. Kawaguchi M, Kato H, Tomita H, Hara A, Suzuki N, Miyazaki T and Matsuo M. Comparison of imaging findings between human papillomavirus-positive and -negative squamous cell carcinomas of the maxillary sinus. J Clin Imaging Sci 10: 59, 2020
7. Kato H, Kanematsu M, Watanabe H, Kawaguchi S, Mizuta K and Aoki M. Differentiation of extranodal non-Hodgkins lymphoma from squamous cell carcinoma of the maxillary sinus: A multimodality imaging approach. Springerplus 4: 228, 2015
8. Kato H, Kanematsu M, Sakurai K, Mizuta K, Aoki M, Hirose Y, Kawaguchi S, Fujita A, Ikeda K and Kanda T. Adenoid cystic carcinoma of the maxillary sinus: CT and MR imaging findings. Jpn J Radiol 31(11): 744-749, 2013
9. Kawaguchi M, Kato H, Tomita H, Mizuta K, Aoki M, Hara A and Matsuo M. Imaging characteristics of malignant sinonasal tumors. J

Clin Med 6(12): 116, 2017
10. Chan KC, Pharoah M, Lee L, Weinreb I and Perez-Ordonez B. Intraosseous mucoepidermoid carcinoma: A review of the diagnostic imaging features of four jaw cases. Dentomaxillofac Rad 42(4): 20110162, 2013
11. Robinson L, Abreu LG, Fonseca FP, Hunter KD, Ambele MA and van Heerden WFP. Ameloblastic carcinoma: A systematic review. J Oral Pathol Med 53(3): 174-181, 2024
12. Li J, Geng ZJ, Lv XF, Zhang XK and Xie CM. Computed tomography and magnetic resonance imaging findings of malignant fibrous histiocytoma of the head and neck. Mol Clin Oncol 4(5): 888-892, 2016
13. Beachler DC and Engels EA. Chronic sinusitis and risk of head and neck cancer in the US elderly population. JAMA Otolaryngol Head Neck Surg 143(1): 25-31, 2017