Normal and Pathologic States of Reconstructed Sagittal CT images in the Maxilla using 64 Multi-detector CT

Miya Kato,1 Masashi Sakayanagi,2 Masataka Kato,2 Yuzo Fujita,2 Shintaro Mori,2 and Takashi Kaneda2

1Nihon University Graduate School of Dentistry at Matsudo, Dental Radiology, Matsudo, Chiba 271-8587, Japan
2Department of Radiology, Nihon University School of Dentistry at Matsudo, Matsudo, Chiba 271-8587, Japan

Correspondence to:
Miya Kato
E-mail: kamada.miya@nihon-u.ac.jp

Abstract
The purposes of this study were 1) to depict normal and pathologic states in reconstructed sagittal images of the maxilla, and 2) to assess how much additional information could be gained by the routine use of sagittal images. In normal subjects, we made a comparison between sagittal and axial images of ten anatomical structures in the maxilla among 100 CT images and analyzed the data with Mann–Whitney’s U-test. A pathologic study of 50 cases included 25 cases of odontogenic maxillary sinusitis, 7 pleomorphic adenomas, 10 postoperative maxillary cysts, and 8 nasopalatine duct cysts. We made a comparison between axial and sagittal images regarding the position and extent of the pathological lesions. In the result of normal subjects, the diagnostic value of sagittal images for assessment of the maxilla was statistically significant for 9 of 10 anatomical structures in the maxilla. In the pathologic study, the sagittal images showed lesions in the maxilla of all 50 patients. Sagittal images were superior to axial images for observing the relationship between these lesions and the maxilla. In conclusion, this study has shown that reconstructed sagittal CT images add diagnostic information to that obtained from axial images. Reconstructed sagittal images are therefore recommended as a supplement to axial plane CT imaging in the evaluation of lesions in the maxilla.

Keywords:
multi-detector computed tomography (MDCT), sagittal image, reconstructed image

Introduction
The use of computed tomography (CT) as a clinical imaging technique is increasing. Recently, multi-detector CT (MDCT) has been developed and used diagnosis of many pathologic conditions in clinically (1, 2).

Multi-detector CT performs a volume scan examination and the images are evaluated by multiplaner reconstruction (MPR) for making a clinical diagnosis. The position and extent of lesions relative to other anatomical structures are important considerations in planning surgical methods and managing patient treatment for optimal prognosis. Computed tomography is one of the most effective techniques for defining the extent and pathologic state of a lesion and is a routine examination for the diagnosis of dento-maxillo-facial lesions (3–5). These CT exams routinely use the axial plane; however, axial imaging of anatomical structures does not always provide the best perspective. For example, reconstructed pre-implant CT images are more useful images than axial or direct coronal images in clinical situations. Few studies have examined the usefulness of reconstructed sagittal images using MDCT for the diagnosis of maxillary lesions.

The purposes of this study were 1) to depict normal and pathologic states in reconstructed sagittal images of the maxilla, and 2) to assess how much additional information could be gained by the routine use of sagittal images.

Materials and Methods
Normal subjects
We reviewed 100 CT images of the maxilla
obtained from 56 women and 44 men (mean age, 51.9 years; range, 13 to 83 years) who were examined for various problems of the mandible not related to the maxilla and maxillary sinususes between April 2006 and October 2006 in our department.

Sagittal images were reconstructed parallel to the naso-meatal line and axial images were reconstructed parallel to the nasal septum with a slice thickness of 3 mm. Computed tomography findings of the maxilla were analyzed regarding ten anatomical structures: 1) the floor of the maxillary sinus, 2) the maxillary sinus ostium, 3) the posterior wall of the maxillary sinus, 4) the pterygopalatine fossa, 5) the greater palatine canal and foramen, 6) the nasopalatine duct, 7) the floor of the orbit, 8) the shape of hard palate, 9) the shape of the dental root and the surrounding alveolar bone, and 10) the nasolacrimal duct. The images were interpreted by two radiologists. Sagittal images were interpreted first without information from the axial images. Axial images were interpreted immediately following interpretation of the sagittal images. For the purpose, we made a comparison between sagittal and axial images regarding each of the ten anatomical structures in the maxilla. The point of this comparison was to determine which image more accurately depicted the position and configuration of the anatomical structures in the maxilla. The point system used to compare sagittal and axial images among anatomical structures in the maxilla is shown in Table 1. The data from this examination was analyzed with the Mann–Whitney’s U-test.

Pathologic study

The 50 patients of this study were 22 women and 28 men (mean age, 45.8 years; range, 22 to 69 years) who underwent CT scanning for suspected maxillary lesions between April 2006 and October 2006. The confirmed findings were 25 cases of odontogenic maxillary sinusitis, 7 pleomorphic adenomas, 10 postoperative maxillary cysts (POMC), and 8 nasopalatine duct cysts.

The images were interpreted by two radiologists. Sagittal images were interpreted first without information from the axial images. Axial images were interpreted immediately following interpretation of the sagittal images. We made a comparison between the axial and sagittal images regarding the position and extent of the lesions, and chose which image more accurately depicted the position and extent of each lesion. All of the CT examinations were performed with the AQUILION 64 computed tomography system (Toshiba Medical, Tokyo, Japan) operated at 120 kV with 80–100 mA (Real Exposure Control), a slice thickness of 0.5 mm, and a helical pitch of 41 with a bony window (window width, 2800; window level, 500).

Results

Normal subjects

The average scores of each structure in the maxilla obtained from this examination with sagittal images were 1) the floor of the maxillary sinus, 5.0; 2) the maxillary sinus ostium, 4.3; 3) the posterior wall of the maxillary sinus, 4.0; 4) the pterygopalatine fossa, 3.0; 5) the greater palatine canal and foramen, 4.0; 6) the nasopalatine duct, 3.9; 7) the floor of the orbit, 5.0; 8) the shape of hard palate, 4.1; 9) the shape of the dental root and the area around the alveolar bone, 4.4; and 10) the nasolacrimal duct, 3.9. The average scores of each structure in the maxilla obtained with axial images were 1) the floor of the maxillary sinus, 1.0; 2) the maxillary sinus ostium, 1.7; 3) the posterior wall of the maxillary sinus, 2.0; 4) the pterygopalatine fossa, 3.0; 5) the greater palatine canal and foramen, 2.0; 6) the nasopalatine duct, 2.1; 7) the floor.

Table 1. Visual assessment of sagittal and axial images among anatomical structures in the maxilla

<table>
<thead>
<tr>
<th>Sagittal images compared with axial images</th>
<th>Sagittal images</th>
<th>Axial images</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely well observed</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Well observed</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Equally observed</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Poorly observed</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Very poorly observed</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>
of the orbit, 1.0; 8) the shape of hard palate, 1.9; 9) the shape of the dental root and the area around the alveolar bone, 1.6; and 10) the nasolacrimal duct, 2.1. The distribution of average scores in each of the anatomical structures in the maxilla is summarized in Table 2. There were statistically significant differences among nine anatomical structures in the maxilla: the floor of the maxillary sinus, the maxillary sinus ostium (Fig. 1), the posterior wall of the maxillary sinus, the greater palatine canal and foramen, the nasopalatine duct, the floor of the orbit, the shape of hard palate, the shape of the dental root and the surrounding alveolar bone, and the nasolacrimal duct (p<0.01) (Fig. 2).

Pathologic study
Sagittal images of all four kinds of maxillary lesions in all 50 cases were found to be superior to axial images for more accurately depicting the position and extent of each lesion. Lesions consisted of odontogenic maxillary sinusitis (Fig. 3), postoperative maxillary cysts (Fig. 4), nasopalatine duct cysts (Fig. 5), and pleomorphic adenomas with clear bone resorption in the hard palate (Fig. 6).

Table 2. The average points of the anatomical structures in the maxilla with sagittal and axial images in normal subjects

<table>
<thead>
<tr>
<th>The structures in the maxilla</th>
<th>Sagittal images</th>
<th>Axial images</th>
</tr>
</thead>
<tbody>
<tr>
<td>The floor of the maxillary sinus</td>
<td>5.0*</td>
<td>1.0</td>
</tr>
<tr>
<td>The maxillary sinus ostium</td>
<td>4.3*</td>
<td>1.7</td>
</tr>
<tr>
<td>The posterior wall of the maxillary sinus</td>
<td>4.0*</td>
<td>2.0</td>
</tr>
<tr>
<td>The pterygopalatine the fossa</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>The greater palatine canal and foramen</td>
<td>4.0*</td>
<td>2.0</td>
</tr>
<tr>
<td>The nasopalatine duct</td>
<td>3.9*</td>
<td>2.1</td>
</tr>
<tr>
<td>The floor of the orbit</td>
<td>5.0*</td>
<td>1.0</td>
</tr>
<tr>
<td>The shape of hard palate</td>
<td>4.1*</td>
<td>1.9</td>
</tr>
<tr>
<td>The shape of the dental root and the surrounding alveolar bone</td>
<td>4.4*</td>
<td>1.6</td>
</tr>
<tr>
<td>The nasolacrimal duct</td>
<td>3.9*</td>
<td>2.1</td>
</tr>
</tbody>
</table>

(*: p<0.01)

Fig. 1a. Computed tomography imaging of the anatomy of the maxillary ostium
a. A sagittal image shows the maxillary ostium (arrow).

Fig. 1b. An axial image shows the maxillary ostium (arrow).
Fig. 2. Computed tomography imaging of the anatomy of the floor of the maxillary sinus, the nasolacrimal duct, the greater palatine canal and foramen, the nasopatine duct, the floor of the orbit, the shape of hard palate, and the shape of the dental root and the surrounding alveolar bone.

a. A sagittal image shows the greater palatine canal (arrow) and foramen (arrow).
b. A sagittal image shows the floor of the maxillary sinus, the shape of the dental root and the surrounding alveolar bone, the floor of the orbit (arrow), and the greater palatine canal (arrowhead). The dental root and the surrounding alveolar bone can be observed in the image as in a pantomogram.
c. A sagittal image shows the nasolacrimal duct (arrow).
d. A sagittal image shows the shape of the hard palate (arrowheads) and the nasopatine duct (arrow).
e. An axial image shows the nasopatine duct (arrow), the shape of the dental root and the surrounding alveolar bone, and the floor of the maxillary sinus (arrowheads).
f. An axial image shows the greater palatine foramen (arrows) and the shape of the hard palate.
g. An axial image shows the greater palatine canal (arrows).
h. An axial image shows the nasolacrimal duct (arrow), the posterior wall of the maxillary sinus (arrowheads), and the pterygopalatine fossa (black arrow).

Fig. 3. Odontogenic maxillary sinusitis in the right maxillary sinus.

a. An axial image shows a low density area around the roots of the right upper first molar (arrows) and the floor of the maxillary sinus. The relationship between the dental disease and mucosal thickening is not clear from this image.
b. A sagittal image shows mucosal thickening only on the floor of the maxillary sinus (arrowheads) with periodontitis of the upper first molar in the same slice. In one part of the bone, the continuity of the periodontitis disappears (arrowhead).
Fig. 4.  Postoperative maxillary cysts in the right maxillary sinus
a. An axial image shows swelling forward (arrowheads).
b. A sagittal image shows two cysts in the right maxilla (arrows). The upward cyst has swollen forward and is approaching the floor of the orbit with pushing up on the floor of the orbit (arrowheads).

Fig. 5.  Nasopalatine duct cyst in the maxilla
a. An axial image shows the cyst with bony expansion (arrowheads).
b. A sagittal image shows the front tooth and the cyst with bony expansion. This image clearly shows the cyst pushing up the floor of the nasal cavity (arrowheads).

Discussion

Computed tomography imaging provides important data for understanding the anatomical structures in the maxilla (6–9). In this study, we performed an examination that compared sagittal images with axial images in the maxilla. Sagittal images more clearly depicted almost all structures in the maxilla compared with axial images in this examination. For normal subjects, the diagnostic value of sagittal images for assessment of the maxilla was statistically significant regarding the maxillary sinus ostium, the floor of the maxillary sinus, the nasolacrimal duct, the greater palatine canal and foramen, the nasopalatine duct, the floor of the orbit, the shape of hard palate, and the shape of the dental root and the surrounding alveolar bone.
Among the maxillary anatomical structures, the floor of the maxillary sinus, the floor of the orbit, and the hard palate are approximately parallel to the axial plane; therefore, it is difficult to observe these structures with axial images. However, they are clearly observed with sagittal images. Conversely, the maxillary sinus ostium, greater palatine canal, and nasopalatine duct are not parallel to the axial plane. We can observe these structures with both axial and sagittal images, but fewer sagittal images than axial images are needed to reconstruct entire images. Hilger et al. (10) suggested that reconstructed sagittal images of the lateral nasal wall are helpful for functional endoscopic sinus surgery (FESS). However, few reports have described the usefulness of reconstructed sagittal images for observation of the anatomical structures in the maxilla.

In our pathological study, we could clearly observe all four types of lesions in the maxilla. Odontogenic maxillary sinusitis is often caused by periapical abscess, extensive marginal periodontitis, or perforation of the maxillary sinus floor at the time of tooth extraction. Therefore, we are required to make a diagnosis of odontogenic maxillary sinusitis whether there is evidence of dental disease in the upper molars (3, 4). In this study, 25 cases of maxillary sinusitis were better depicted by sagittal images than by axial images. Thickening of the mucous membrane in cases of odontogenic maxillary sinusitis is caused by dental disease. We could observe the condition of dental disease and the floor of the maxillary sinus in the same slices with sagittal images. However, with axial images, dental disease condition, the state of mucosal abnormalities, and the floor of the maxillary sinus were observed in separate slices. Therefore, we could not observe the relationship between dental disease condition and thickening of mucous membrane clearly with axial images (Fig. 3). A POMC is a cystic lesion in the maxilla that appears 10–30 years following maxillary sinus surgery, especially the Caldwell–Luc procedure for maxillary sinusitis. This lesion has been reported to account for 20% of the oral cystic lesions diagnosed in Japan (11). The incidence of this cyst is known to be much higher in the Japanese population than in the world. It is important to observe the relationship between bony expansion of the cyst and the wall of the maxillary sinus. In this study, sagittal images clearly showed the relationship between the cyst and the floor of the orbit, especially compared to axial images (Fig. 4). Nasopalatine duct cyst is a non-odontogenic cyst that typically appears round or
ovoid on CT images, with swelling of the anterior part of the palate (12-14). Sagittal images clearly indicated the position and relationship between bony expansion of the cyst and the nasopalatine duct compared to axial images (Fig. 5). In our study, we observed seven cases of pleomorphic adenoma of the palatal salivary gland in the palate. Some histological types of benign and malignant neoplasms can occur in the palatal salivary gland. Malignant tumors occur more frequently in the minor salivary glands than in the major salivary glands. High malignancy rates of palatal salivary gland tumors are reported (15). There is often bone resorption in the hard palate with these tumors. In this study, bone resorption of the hard palate was more clearly observed in sagittal images compared to axial images. Therefore, hard palate lesions require sagittal imaging for the diagnosis of a bony condition (Fig. 6). The results of this comparison between sagittal and axial images suggest that there is value in adding sagittal images for the diagnosis of lesions in the maxilla that are frequently difficult to accurate diagnose with only axial images. In addition, reconstructed images can be used without additional irradiation using MDCT. Therefore, we think that the routine use of reconstructed sagittal images has a potential to increase diagnostic accuracy regarding lesions in the maxilla.

In conclusion, this study has shown that CT images in the form of reconstructed sagittal images add diagnostic information to the axial images. Reconstructed sagittal images are therefore recommended as a supplement to axial plane CT imaging in the evaluation of lesions in the maxilla.

References