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Abstract: Distinguishing normal parts of the nasopalatine duct from nonodontogenic nasopalatine duct cysts can be difficult. This study aimed to establish the characteristic imaging findings of the nasopalatine duct region on multidetector-row computed tomographic (MDCT) images.

The subjects were 122 patients (61 males, 61 females; mean age, 49.8 years; age range, 17-88 years) who underwent 64-MDCT imaging of the maxilla after providing informed consent. Anatomic variants of the nasopalatine duct were classified using coronal slices. Measurements of the duct width diameters and the distances from the nasopalatine foramen to the incisive foramen as a major axis were performed using sagittal and coronal slices. CT values for the duct portion with maximum diameter were measured using axial slices. Regarding anatomic variations, 69 patients (56.5 %) had a single duct, 13 patients (10.7 %) had two parallel ducts, and 40 patients (32.8 %) had Y-type ducts. The mean width diameter of the nasopalatine duct on sagittal slices was 3.2 mm in the nasopalatine foramen, 2.7 mm in the middle point, and 3.8 mm in the incisive foramen. The mean width diameter of the nasopalatine duct on coronal slices was 4.3 mm in the nasopalatine foramen, 3.6 mm in the middle point, and 3.8 mm in the incisive foramen. The mean CT value in males and females was 122.4 ± 77.9 HU.

Although the nasopalatine duct shows great variability in morphological appearance, characteristic findings for the nasopalatine duct region on MDCT images have been established in this study.

Key words: Nasopalatine duct, Nasopalatine duct cyst, Incisive canal, Incisive canal cyst

Introduction

The nasopalatine duct originates at two foramina in the floor of the nasal cavity. The openings are on each side of the nasal septum, close to the anteroinferior border of the nasal cavity, and each canal passes downward somewhat anteriorly and medially to unite with the canal from the other side in a common opening, the nasopalatine foramen. In pathological conditions, a nasopalatine duct cyst may develop from epithelial residues in the nasopalatine duct. A nasopalatine duct cyst is a nonodontogenic developmental cyst that arises in the nasopalatine duct near the anterior palatine papilla. It is the most common type of nonodontogenic cyst, and may arise from epithelial remnants in the nasopalatine duct. Such cysts can occur at any age, but are most frequently found in the fourth and sixth decades of life, with no sex predilection. Takagi et al. reported that squamous cell carcinoma can develop in the lining epithelium of a nasopalatine duct cyst. Therefore, differentiation between the normal nasopalatine duct and duct lesions is very important in clinical situations.

Many of these cysts are small, and are found on routine plain films in radiographic surveys. It may be difficult to differentiate between an enlarged nasopalatine duct and a nasopalatine duct lesion in images. However, a nasopalatine duct cyst is always located at or near the midline and is usually round or ovoid, although it may be heart-shaped. Therefore, judgment of size in normal states of the nasopalatine duct on computed tomographic (CT) images and pathologic states of the nasopalatine duct is sometimes difficult in clinical situations. Moreover, depiction of the normal part of the duct on a CT image is indispensable for a differential diagnosis compared with a pathologic image; and reports on this issue remain scarce.

The purpose of this study was to investigate the characteristic imaging findings of the nasopalatine duct region using multidetector-row CT (MDCT).

Materials and Methods

This study was approved by the Ethics Committee of the Nihon University School of Dentistry at Matsudo.
University School of Dentistry (No. EC12-009), and all patients signed an informed consent agreement for the MDCT examination.

MDCT images of the maxilla obtained from 61 males and 61 females (mean age, 49.8 years; range, 17-88 years) who underwent 64-MDCT in the Department of Radiology at our University Hospital from April 2012 to August 2012 were evaluated. Patients with evident maxilla pathology, metal artifacts precluding visualization of the maxilla, and no maxillary central incisors were excluded from the study.

Image protocol and evaluation

CT imaging was performed with a 64-MDCT system (Aquilion 64; Toshiba Medical Systems, Tokyo, Japan). All patients were scanned using the routine clinical protocol for craniofacial examination at our hospital as follows: tube voltage, 120 kV; tube current, 100 mA; field of view, 240 × 240 mm; helical pitch, 41. The imaging included axial (0.50 mm), multiplanar (3.00 mm), and three-dimensional (3D) images. The MDCT images were interpreted using a medical liquid crystal display monitor (RadiForce G31; Eizo Nanao, Ishikawa, Japan).

Analysis of the shape of the nasopalatine duct was performed on the MDCT images. The anatomic characteristics of the nasopalatine duct were evaluated using coronal slices. The anatomic variants of the nasopalatine duct were differentiated into three groups (Fig. 1): (a) single duct; (b) two parallel ducts; and (c) variations of Y-type ducts with one oral/palatal opening and two or more nasal openings. Measurements of width diameters (in millimeters) of the nasopalatine duct were performed at three points, nasopalatine foramen, middle point of the nasopalatine duct, and incisive foramen, using sagittal and coronal slices. The distance (in millimeters) from the nasopalatine foramen to the incisive foramen was measured as a major axis diameter using sagittal and coronal slices. The following landmarks were selected for standardized measurements (Fig. 2): diameter of the nasopalatine foramen; diameter of the middle point of the nasopalatine duct; diameter of the incisive foramen; and length of the nasopalatine duct. In addition, the CT values of the portion of the nasopalatine duct with the maximum diameter were measured using axial slices.

All images were independently evaluated by two oral radiologists, and any differences were resolved by forced consensus. The statistical significance of differences in data was determined by a two-sided Mann-Whitney U test. Differences with values of $P < 0.05$ were considered significant.

Results

Classification of anatomic variations of the nasopalatine duct was performed using reformatted coronal slices from the 64-MDCT scans (Table 1). Evaluation of the different anatomic
variations of the nasopalatine duct resulted in the following findings: 69 patients (56.5 %) had a single duct; 13 patients (10.7 %) had two parallel ducts; and 40 patients (32.8 %) had Y-type ducts.

Analysis of the nasopalatine duct was carried out using reformed sagittal slices from the 64-MDCT scans (Table 2). The mean width diameter of the nasopalatine duct at the nasopalatine foramen was 3.2 ± 1.3 mm, while that at the middle point of the duct was 2.7 ± 0.9 mm, and that at the incisive foramen was 3.1 ± 0.9 mm in all patients. The mean major axis of the nasopalatine duct was 14.0 ± 2.6 mm in all patients. The maximum width diameter of the nasopalatine duct at the nasopalatine foramen was 6.3 mm, while that at the middle point of the duct was 5.1 mm, and that at the incisive foramen was 5.8 mm in all patients. The maximum major axis of the nasopalatine duct was 21.4 mm in all patients. The minimum width diameter of the nasopalatine duct at the nasopalatine foramen was 0.6 mm, while that at the middle point of the duct was 0.7 mm, and that at the incisive foramen was 0.8 mm in all patients. The minimum major axis of the nasopalatine duct was 5.6 mm in all patients.

Analysis of the nasopalatine duct was also carried out using reformed coronal slices from the 64-MDCT scans (Table 3). The mean width diameter of the nasopalatine duct at the nasopalatine foramen was 4.3 ± 1.1 mm, while that at the middle point of the duct was 3.6 ± 1.0 mm, and that at the incisive foramen was 3.8 ± 1.0 mm in all patients. The mean major axis of the nasopalatine duct was 14.0 ± 2.6 mm in all patients. The maximum width diameter of the nasopalatine duct at the nasopalatine foramen was 6.8 mm, while that at the middle point of the duct was 6.4 mm, and that at the incisive foramen was 6.2 mm in all patients. The maximum major axis of the nasopalatine duct was 21.4 mm in all patients. The minimum width diameter of the nasopalatine duct at the nasopalatine foramen was 1.7 mm, while that at the middle point of the duct was 1.0 mm, and that at the incisive foramen was 1.1 mm in all patients. The minimum major axis of the nasopalatine duct was 5.4 mm in all patients.

Table 1. Classification of Anatomic Variations of the Nasopalatine Duct Using Reformatted Coronal Slices from 64-MDCT Imaging

<table>
<thead>
<tr>
<th></th>
<th>Single duct</th>
<th>Two parallel ducts</th>
<th>Y-type duct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males (n=61)</td>
<td>34 (55.7 %)</td>
<td>3 (5.0 %)</td>
<td>24 (39.3 %)</td>
</tr>
<tr>
<td>Females (n=61)</td>
<td>35 (57.4 %)</td>
<td>10 (16.4 %)</td>
<td>16 (26.2 %)</td>
</tr>
<tr>
<td>Males and females (n=122)</td>
<td>69 (56.5 %)</td>
<td>13 (10.7 %)</td>
<td>40 (32.8 %)</td>
</tr>
</tbody>
</table>

Data are shown as n (%).

Table 2. Analysis of the Nasopalatine Duct Using Reformatted Sagittal Slices from 64-MDCT Imaging

<table>
<thead>
<tr>
<th></th>
<th>Nasopalatine foramen</th>
<th>Middle point</th>
<th>Incisive foramen</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (mm)</td>
<td>3.2±1.3</td>
<td>2.7±0.9</td>
<td>3.1±0.9</td>
<td>14.0±2.6</td>
</tr>
<tr>
<td>Maximum (mm)</td>
<td>6.3</td>
<td>5.1</td>
<td>5.8</td>
<td>21.4</td>
</tr>
<tr>
<td>Minimum (mm)</td>
<td>0.6</td>
<td>0.7</td>
<td>0.8</td>
<td>5.6</td>
</tr>
</tbody>
</table>

Data are shown as means ± SD.

Table 3. Analysis of the Nasopalatine Duct Using Reformatted Coronal Slices from 64-MDCT Imaging

<table>
<thead>
<tr>
<th></th>
<th>Nasopalatine foramen</th>
<th>Middle point</th>
<th>Incisive foramen</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (mm)</td>
<td>4.3±1.1</td>
<td>3.6±1.0</td>
<td>3.8±1.0</td>
<td>11.6±2.4</td>
</tr>
<tr>
<td>Maximum (mm)</td>
<td>6.8</td>
<td>6.4</td>
<td>6.2</td>
<td>17.3</td>
</tr>
<tr>
<td>Minimum (mm)</td>
<td>1.7</td>
<td>1.0</td>
<td>1.1</td>
<td>5.4</td>
</tr>
</tbody>
</table>

Data are shown as means ± SD.

Table 4. Effect of Sex on the Diameters of the Nasopalatine Duct Using Reformatted Sagittal Slices from 64-MDCT Imaging

<table>
<thead>
<tr>
<th></th>
<th>Nasopalatine foramen</th>
<th>Middle point</th>
<th>Incisive foramen</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males (n=61)</td>
<td>3.4±1.1</td>
<td>2.9±0.9</td>
<td>3.3±0.9</td>
<td>14.5±2.4</td>
</tr>
<tr>
<td>Females (n=61)</td>
<td>2.9±1.1</td>
<td>2.4±0.8</td>
<td>2.8±0.9</td>
<td>13.4±2.6</td>
</tr>
<tr>
<td>P-value</td>
<td>0.01</td>
<td>0.01</td>
<td>0.002</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Data are shown as means ± SD.

Table 5. Effect of Sex on the Diameters of the Nasopalatine Duct Using Reformatted Coronal Slices from 64-MDCT Imaging

<table>
<thead>
<tr>
<th></th>
<th>Nasopalatine foramen</th>
<th>Middle point</th>
<th>Incisive foramen</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males (n=61)</td>
<td>4.5±1.2</td>
<td>3.7±1.1</td>
<td>3.8±1.0</td>
<td>11.9±2.7</td>
</tr>
<tr>
<td>Females (n=61)</td>
<td>4.2±1.0</td>
<td>3.6±0.8</td>
<td>3.8±0.9</td>
<td>11.3±2.2</td>
</tr>
<tr>
<td>P-value</td>
<td>0.10</td>
<td>0.54</td>
<td>0.86</td>
<td>0.14</td>
</tr>
</tbody>
</table>

Data are shown as means ± SD.
The maximum major axis of the nasopalatine duct was 17.3 mm in all patients. The minimum width diameter of the nasopalatine duct at the nasopalatine foramen was 1.7 mm, while that at the middle point of the duct was 1.0 mm, and that at the incisive foramen was 1.1 mm in all patients. The minimum major axis of the nasopalatine duct was 5.4 mm in all patients.

The effect of sex on the diameters of the nasopalatine duct was investigated using reformatted sagittal slices from the 64-MDCT scans (Table 4). The mean width diameter of the nasopalatine duct at the nasopalatine foramen was 3.4 ± 1.1 mm in males and 2.9 ± 1.1 mm in females (P < 0.05), while that at the middle point of the duct was 2.9 ± 0.9 mm in males and 2.4 ± 0.8 mm in females (P < 0.05), and that at the incisive foramen was 3.3 ± 0.9 mm in males and 2.8 ± 0.9 mm in females (P < 0.05). The mean major axis of the nasopalatine duct was 14.5 ± 2.4 mm in males and 13.4 ± 2.6 mm in females (P < 0.05).

The effect of sex on the diameters of the nasopalatine duct was also investigated using reformatted coronal slices from the 64-MDCT scans (Table 5). The mean width diameter of the nasopalatine duct at the nasopalatine foramen was 4.5 ± 1.2 mm in males and 3.6 ± 0.8 mm in females (P = 0.54), and that at the incisive foramen was 3.8 ± 1.0 mm in males and 3.8 ± 0.9 mm in females (P = 0.86). The mean major axis of the nasopalatine duct was 11.9 ± 2.7 mm in males and 11.3 ± 2.2 mm in females (P = 0.14).

The mean CT value in males and females was 122.4 ± 77.9 HU.

**Discussion**

The results of the present study indicate that the nasopalatine duct shows much variability with regard to its morphological appearance. Classification of anatomic variations of the nasopalatine duct using coronal slices in males and females revealed 56.5 % with a single duct, 10.7% with two parallel ducts, and 32.8 % with Y-type ducts. The mean width diameter of the nasopalatine duct using sagittal slices was 3.2 mm at the nasopalatine foramen, 2.7 mm at the middle point of the duct, and 3.1 mm at the incisive foramen in all patients. The mean width diameter of the nasopalatine duct using coronal slices was 4.3 mm at the nasopalatine foramen, 3.6 mm at the middle point of the duct, and 3.8 mm at the incisive foramen in all patients.

Fernández-Alonso et al. reported the following anatomic variations in coronal slices: Y-type canals were most frequent at 48.6%, a single canal was observed in 41.1 %, and two parallel canals were observed in 10.3 %

Suter et al. reported that a single duct was identified in 45 % of cases, Y-type ducts in 40 % of cases, and two parallel ducts in 15 % of cases. These frequencies of the anatomic variations of the nasopalatine duct are similar to our results.

Ling et al. reported that the major axis of the nasopalatine duct was longer in a dentate group compared with an edentulous group, and described that the width diameter showed a trend toward enlargement with aging. From our measurement results, the mean width diameter of the duct at all points using sagittal slices differed significantly between males and females. The mean major axis of the nasopalatine duct using sagittal slices also differed significantly between males and females. From these findings, the possibility that the width diameter and the major axis diameter of the nasopalatine duct were influenced by the size of the upper jawbone was suggested.

The nasopalatine duct contains the nasopalatine nerve, nasopalatine artery, greater palatine nerve, and greater palatine artery. In addition, the nasopalatine duct is made of stratified squamous epithelium and ciliated columnar epithelium. Therefore, development cysts can arise from spontaneous proliferation of epithelial remnants of the nasopalatine duct between the oral and nasal cavities. Accordingly, these cysts are usually lined by a stratified squamous epithelium or combination of stratified squamous epithelium and respiratory epithelium, and a postulated respiratory epithelium (pseudo-stratified, ciliated, and columnar) is likely to be observed if the cysts are located more nasally.

According to Swanson et al., the mean radiographic diameter of nasopalatine duct cysts was 17.1 mm, but 75 % of the lesions were d"20 mm in diameter. Symptoms were present in at least 70% of cases. Only 28% of specimens contained respiratory epithelium. Recurrence was noted in only 2 % of cases.

According to Suter et al., the mean width diameter of nasopalatine duct cysts on coronal CBCT images was 12.5 mm. Also, the minimum width diameter of nasopalatine duct cysts on coronal CBCT images was 5.5 mm, while the maximum width diameter was 32.6 mm. From these findings, cases with a nasopalatine duct of more than 5.5 mm in diameter on coronal CT images may be suggestive of a nasopalatine duct cyst. Nicholas et al. reported that it is difficult to differentiate a small nasopalatine duct cyst from a large nasopalatine duct. However, it has been proposed that a nasopalatine duct of <6 mm on an occlusal radiograph is within the normal limits, provided that the patient has no symptoms or abnormal clinical findings. From our measurement results, the maximum width diameter of the normal nasopalatine duct was about 6 mm, and this size of the nasopalatine duct cyst is likely to be observed if the cysts are located more nasally.

The mean CT value of the nasopalatine duct was 122.4 HU in the present study. MDCT has the advantages of high extraction ability of soft tissue and excellent diagnostic ability of neoplastic lesions. In addition, it is considered to be effective for diagnosis in the nasopalatine duct region, because quantitation can be achieved by the CT value. The human eye cannot distinguish a
The nasopalatine duct is mainly composed of nerve and blood vessels. A recent report suggested that the nerve and vessel CT value was 80–90 HU\(^{11}\). However, our CT value was higher than this previously reported range. Nandalur et al. reported that the CT value was changed to about 70–1200 HU by fibrosis and calcification of plaque\(^{12}\). The CT values of blood vessels may be elevated by intravascular plaque\(^{12}\). Therefore, it was considered that the CT value of the nasopalatine duct was over 100 HU\(^{1,10-12}\).

In conclusion, the findings for the nasopalatine duct region on MDCT images have been elucidated in this study.

**Conflict of Interest**

The authors have declared that no COI exists.

**References**
