Sex and Age Differences in the Bony Nasolacrimal Canal

An Anatomical Study

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Objectives: To determine the diameters of the bony nasolacrimal canal and to evaluate how they are affected by sex and age.

Methods: Standard axial sinus computed tomographic images of 314 patients were assessed retrospectively; the anteroposterior and transverse diameters, the sectional area of the bony nasolacrimal canal at the level of the infraorbital margin, and the angle between the bony canal and the nasal floor were measured.

Results: The mean results were as follows: anteroposterior diameter, 5.6 mm; transverse diameter, 5.0 mm; sectional area of the bony nasolacrimal canal, 22.6 mm²; and angle between the bony canal and the nasal floor, 78.3°. Females had a significantly smaller anteroposterior diameter (mean 0.6 mm) and a significantly smaller transverse diameter (mean 0.3 mm). The sectional area of the bony nasolacrimal canal was 13% smaller in females ($P < .001$). The angle between the bony canal and the nasal floor was a mean of 1.1° more obtuse in males ($P = .004$). With age, the transverse diameter, the sectional area of the bony nasolacrimal canal, and the angle between the bony canal and the nasal floor in males, and the anteroposterior diameter, the sectional area of the bony nasolacrimal canal, and the angle between the bony canal and the nasal floor in females increased significantly.

Conclusions: In females, the narrowness of the bony nasolacrimal canal and the acute angle between the bony canal and the nasal floor predispose to chronic inflammation of the nasolacrimal drainage system. The results of this quantitative anatomical study may explain why primary acquired nasolacrimal duct obstruction is more frequent in younger female patients.

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EPIPHORA CAUSED BY NASOLACRIMAL DUCT OBSTRUCTION IS A COMMON OPHTHALMIC PROBLEM AND ACCOUNTS FOR 3% OF ALL OPHTHALMIC CLINIC VISITS. OBSTRUCTION OF THE NASOLACRIMAL DRAINAGE SYSTEM CAN BE CONGENITAL OR ACQUIRED. BARTLEY CLASSIFIED ACQUIRED LACRIMAL DUCT OBSTRUCTION INTO PRIMARY AND SECONDARY CAUSES. SECONDARY PROCESSES THAT MAY RESULT IN OBSTRUCTION INCLUDE NEOPLASM, SARCOIDOSIS, INFECTIOUS FACIAL TRAUMA OR SURGERY, OR WEGENER GRANULOMATOSIS. ON THE OTHER HAND, PRIMARY ACQUIRED NASOLACRIMAL DUCT OBSTRUCTION (PANDO) IS IDIOPATHIC, AND SEVERAL CAUSATIVE FACTORS HAVE BEEN PROPOSED. PANDO OCCURS MORE FREQUENTLY IN WOMEN (50%-83% OF CASES) THAN IN MEN; MOST PATIENTS ARE YOUNGER THAN 50 YEARS. THE PROCESS IS CHARACTERIZED BY GRADUAL CHRONIC INFLAMMATION AND FIBROSIS ALONG THE ENTIRE LENGTH OF THE NASOLACRIMAL DUCT, WHICH LEADS TO INCREASING OBSTRUCTION OF THE DRAINAGE SYSTEM. PREVIOUSLY, VARIATIONS IN THE GEOMETRY OF THE BONY NASOLACRIMAL SYSTEM HAVE BEEN THOUGHT TO CORRELATE WITH PATIENT SEX AND AGE. HOWEVER, THERE HAVE BEEN FEW STUDIES THAT HAVE QUANTITATIVELY ASSESSED THE ANATOMY OF THE NORMAL BONY NASOLACRIMAL DRAINAGE SYSTEM. THEREFORE, THE OBJECTIVES OF THIS STUDY WERE TO DETERMINE THE DIAMETERS OF THE BONY NASOLACRIMAL CANAL AND TO EVALUATE HOW THESE DIAMETERS ARE AFFECTED BY PATIENT SEX AND AGE.

Methods: Between January 1, 2002, and December 31, 2004, 368 Japanese patients underwent standard axial sinus computed tomography (CT) for maxillofacial disease at the Saitama Medical Center, Saitama Medical University, Saitama, Japan. We retrospectively evaluated 314 patients with no excess tearing and with no evidence of pathologic conditions affecting the bony nasolacrimal canal. There were 202 males (64%) and 112 (36%) females, with ages ranging from 8 to 86 years (mean age, 49.2 years). The mean age of the males was 49.0 years (age...
range, 8-86 years) and that of the females was 49.6 years (age range, 10-83 years). The patients were diagnosed as having paranasal sinusitis (n = 210 [67%]), mucocele (n = 42 [13%]), benign tumor (including papilloma and angiofibroma) (n = 18 [6%]), epistaxis (n = 17 [5%]), deflected nasal septum (n = 11 [4%], malignant tumor (including squamous cell carcinoma and malignant lymphoma) (n = 5 [2%]), trauma (n = 5 [1.5%]), and others (n = 6 [1.5%]). None of the patients had epiphora. Written informed consent was obtained from all patients; the study protocol was approved by the institutional review board of the Saitama Medical School.

CT TECHNIQUE

The CT studies were performed using a high-speed scanner (General Electric CT HiSpeed Advantage; GE Medical Systems, Milwaukee, Wisconsin). Contiguous 3- to 5-mm axial images were obtained parallel to the orbital floor at 120 kV (peak) and 40 to 300 mA using a bone algorithm.

MEASUREMENTS

The imaging data were transferred to a personal computer (VAIO PCV-RZ55; Sony, Tokyo, Japan) connected to a high-resolution color monitor (SDM-S74H; Sony, Tokyo, Japan). Anatomical measurements were performed using Photoshop CS (Adobe Systems, San Jose, California). Since the smallest diameter is usually located in the middle of the canal, 2 of us (K. S. and H. T.) measured the anteroposterior and transverse diameters, as well as the sectional area of the bony nasolacrimal canal at the level of the infraorbital margin (Figure 1). We measured the most anterior point of the bony nasolacrimal canal on each CT section and calculated the regression line from each point. We also calculated the line of the nasal floor from each computed tomographic section and calculated the regression line from the most anterior point of the hard palate on the CT of each section. We also calculated the line of the nasal floor from each computed tomographic section and calculated the regression line from the most anterior point of the hard palate on the CT of each section and the nasal floor line from the most anteroposterior points (arrowheads) were measured as the angle between the bony canal and the nasal floor.

STATISTICAL ANALYSIS

All analyses were conducted using commercially available software (version 11.0J for Windows; SPSS Software, Chicago, Illinois). The nonparametric Mann-Whitney test was used for sex comparisons. The Kruskal-Wallis test was used for age comparisons. Data are given as mean (SD).

Table 1 gives the measurements of the bony nasolacrimal canal. The anteroposterior and transverse diameters, sectional area of the bony nasolacrimal canal, and the angle of the bony canal and the nasal floor did not differ significantly between the right and left sides. Overall, the anteroposterior diameter of the bony nasolacrimal canal ranged from 0.4 to 10.9 mm (mean, 5.6 mm), and the transverse diameter ranged from 2.2 to 8.7 mm (mean, 5.0 mm). The sectional area of the bony nasolacrimal canal ranged from 2.0 to 69.8 mm² (mean, 22.6 mm²). The angle between the bony canal and the nasal floor ranged from 64.9° to 89.1° (mean, 78.3°).

These data were compared by sex. There was no statistically significant difference between the male and female groups for age distribution (P =.81). The anteroposterior diameter of the bony nasolacrimal canal was significantly greater in male patients (5.8 ± 1.2 mm) than in female patients (5.3 ± 1.2 mm; P < .001). The transverse diameter was significantly greater in male patients (5.1 ± 1.1 mm) than in female patients (4.8 ± 1.1 mm; P = .005). The sectional area of the bony nasolacrimal canal was significantly greater in male patients (23.6 ± 9.1 mm²) than in female patients (20.6 ± 8.5 mm²; P < .001). The angle between the bony canal and the nasal floor was significantly greater in male patients (78.7° ± 4.3°) than in female patients (77.6° ± 4.4°; P = .004).

When the subjects were divided into 4 age groups (Table 2), age significantly affected the transverse diameter (P = .002), the sectional area of the bony nasolacrimal canal (P = .002) and the angle between the bony canal and the nasal floor (P < .001) in male patients (Figure 3) and the anteroposterior diameter (P < .001), the sectional area of the bony nasolacrimal canal (P < .001), and the angle between the bony canal and the nasal floor (P < .001) in female patients. There was a trend
for the anteroposterior diameter to increase with age in male patients \((P = .04)\) and for the transverse diameter to increase with age in female patients \((P = .02)\), although these results were not statistically significant.

### COMMENT

The etiology of PANDO is unknown. Several predisposing factors have been suggested, including cigarette smoking, facial-sinonasal trauma, and a history of dacryocystitis.\(^5\) It is thought that a narrow bony nasolacrimal canal predisposes to the development of lacrimal duct obstruction. However, few studies have assessed the normal diameter of the bony nasolacrimal canal. In the early 20th century, Duke-Elder,\(^5\) based on anatomical observations, reported that the transverse diameter is approximately 4.6 mm. Steinkegler\(^6\) measured epoxy resin casts of macerated skulls and found that the transverse diameter was 4.8 mm and the anteroposterior diameter was 6.8 mm. Cowen and Hurwitz\(^7\) reported that the transverse diameter was 3 to 5 mm and the anteroposterior diameter was 4 to 8 mm. The anteroposterior diameter (mean, 5.6 mm) and the transverse diameter (mean, 5.0 mm) measured in our study are comparable to those previously reported. Janssen et al\(^8\) measured the minimum transverse diameters of the bony nasolacrimal canal in a group of 100 normal adults using axial CT images; the mean transverse diameter was 3.5 mm. The findings from our study showed that the mean diameter of the bony nasolacrimal canal was considerably larger than that reported by Janssen et al. This may be explained by the different measurement methods used. We measured the diameter at the level of the infraorbital margin, while Janssen et al measured the minimum diameter of the bony canal. Furthermore, we evaluated Japanese patients. This difference may be related to the possibility that race differences may exist. Groessl et al\(^9\) reported that there was no difference in diameter between the right and left bony nasolacrimal canals. The results of our study also found that the left and right bony nasolacrimal canals were similar in size. It has been found that the left and right bony nasolacrimal canals usually run parallel to each other and slope downward at a posterior angle of 15° to 25° in the bony wall between the maxillary sinus and the nose.\(^3\) Janssen et al\(^8\) reported that the bony nasolacrimal canal traveled at a 22.5° angle to a line perpendicular to the nasal floor. In our study, the mean angle between the bony canal and the nasal floor was 78.3°; this angle was more acute than that reported in the previous articles.

A few articles have been published on sex differences of the bony nasolacrimal canal. Groessl et al\(^9\) mentioned that the lower nasolacrimal fossa and the middle bony lacrimal duct are significantly smaller in females than in males. Janssen et al\(^8\) documented that female subjects had a significantly smaller minimum diameter (on average 0.35 mm). In our study, female patients had a significantly smaller bony nasolacrimal canal; in female patients the anteroposterior diameter was on average 0.6 mm smaller, and the transverse diameter was on average 0.3 mm smaller. The sectional area of the bony nasolacrimal canal was 13% smaller in female patients than in male patients. Furthermore, the angle between the bony canal and the nasal floor was on average 1.1° more obtuse in male patients than in female patients. To the best of our knowledge, no previous study has compared the angle of the bony nasolacrimal canal between male and female subjects. It is possible that the greater prevalence of PANDO in female subjects is, at least in part, caused by the bony nasolacrimal canal’s smaller diameter. Furthermore, the smaller diameter in female subjects can cause tear fluid stasis and infections from the nasal cavity, since the bony nasolacrimal canal is flatter in females than in males. The sex difference may be attributed to females’ smaller midfacial structures.\(^10\)

Janssen et al\(^8\) studied normal adults ranging in age from 18 to 80 years and found no association between age and the minimum diameter of the bony nasolacrimal canal. Groessl et al\(^9\) reported that, from 20 to 80 years of age in both male and female subjects, the nasolacrimal duct generally enlarged at the level of the inferior fossa and in its

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Table 1. Anatomical Dimensions of the Bony Nasolacrimal Canal

<table>
<thead>
<tr>
<th>Side</th>
<th>No. of Patients</th>
<th>Anteroposterior</th>
<th>Transverse</th>
<th>Sectional Area, mm²</th>
<th>Angle, Degrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>314</td>
<td>5.6 (1.2)</td>
<td>5.0 (1.1)</td>
<td>22.5 (9.0)</td>
<td>78.4 (4.4)</td>
</tr>
<tr>
<td>Left</td>
<td>314</td>
<td>5.7 (1.2)</td>
<td>4.9 (1.1)</td>
<td>22.6 (9.0)</td>
<td>78.3 (4.4)</td>
</tr>
</tbody>
</table>

Table 2. Age Distribution of the Bony Nasolacrimal Canals

<table>
<thead>
<tr>
<th>Sex</th>
<th>No. of Patients in Each Age Group, y</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;20</td>
</tr>
<tr>
<td>Male</td>
<td>12</td>
</tr>
<tr>
<td>Female</td>
<td>4</td>
</tr>
</tbody>
</table>
In our study, it was also found that the caliber of the bony lacrimal duct and the angle between the bony lacrimal duct and the nasal floor generally increased with age, primarily before age 40 years. Groessl et al. noted that the increase in the size of the bony lacrimal duct size was less in female than in male subjects. However, in the present study, female patients had a greater change in the diameter and the angle between the bony canal and the nasal floor. Janssen et al. pointed out that measurement errors would occur if the anteroposterior diameter of the bony canal was measured on axial CT scans because of the backward slope of the bony canal relative to the axial plane and suggested that measurements of the transverse diameter were more reliable. In our study, the measured anteroposterior and transverse diameters were equally scattered. The diameter of the bony nasolacrimal canal was measured at the level of the infraorbital floor on axial CT scans parallel to the orbital floor.

Therefore, the ideal head position was used to measure the diameters of the bony nasolacrimal canal, even though this was a retrospective analysis. At least 80% of patients with congenital nasolacrimal duct obstruction have the condition resolve with conservative management by the age of 12 months. In our study, the bony nasolacrimal canal of children was not examined. Further research is needed to ascertain the relationship between age and the diameter of the bony nasolacrimal canal in children.

In summary, the present study found that the bony nasolacrimal canal was narrower and flatter against the nasal floor in female than in male patients and that the diameter and the sectional angle between the bony canal and the nasal floor generally increased with age up to 40 years. We did not measure the diameter at the smallest diameter. However, the results of this quantitative anatomical study may explain why PANDO is more frequent in female patients younger than 50 years.
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REFERENCES


Archives Web Quiz Winner

Congratulations to the winner of our July quiz, Michael Stur, MD, Vienna, Austria. The correct answer to our July challenge was carcinoma-associated retinopathy syndrome. For a complete discussion of this case, see the Clinicopathologic Reports, Case Reports, and Small Case Series section in the August Archives (Mohamed Q, Harper CA. Acute optical coherence tomographic findings in cancer-associated retinopathy. Arch Ophthalmol. 2007;125[8]:1132-1133).

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