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Morphometric Evaluation of Bony Nasolacrimal Canal in Mongolians with Primary Acquired Nasolacrimal Duct Obstruction

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Objectives: To compare the morphometric differences of the bony nasolacrimal canal in unilateral primary acquired nasolacrimal duct obstruction (PANDO) patients between PANDO and non-PANDO sides and the control group in the Mongolian population. **Methods:** A hospital-based, retrospective case-control design was used for this study. A total of 584 participants were grouped into PANDO patients and the control group. Morphometry of the bony nasolacrimal canal was measured by CT scan. **Results:** The bony nasolacrimal canal's minimum transverse diameter was 3.67 ± 1.96 mm on the PANDO side, 3.98 ± 2.01 mm on the non - PANDO side and 4.03 ± 1.12 mm for the control group ($p > 0.05$). The distal bony nasolacrimal canal transverse diameter was 4.39 ± 1.21 mm for the PANDO side, 4.33 ± 1.32 mm on the non-PANDO side and 5.11 ± 1.25 mm for the control groups ($p < 0.05$). The bony nasolacrimal canal entrance transverse diameter was 4.36 ± 1.59 mm on the PANDO side, 4.43 ± 1.83 mm on the non-PANDO side and 4.69 ± 1.61 mm in the control group ($p < 0.05$). **Conclusion:** Narrower bony nasolacrimal canal morphology may cause a tendency for PANDO development. We identified a narrow distal bony nasolacrimal transverse diameter for both the PANDO and non-PANDO sides of unilateral PANDO patients compared with the control group.

Keywords: Bony Nasolacrimal Canal, Primary Acquired Nasolacrimal Duct Obstruction, Computed Tomography, Nasolacrimal Duct

Introduction

Excessive eye watering is often diagnosed in patients over 70 years of age and is at least 4 times more common in females. The main reason is nasolacrimal duct obstruction [1]. Secondary acquired lacrimal duct obstruction has many different causes [1]. It occurs in the tract of the lacrimal sac and the nasolacrimal duct and is the most frequently caused by facial trauma or surgery, neoplasm, sarcoidosis, or Wegener's granulomatosis, infections, skin burns, drugs for glaucoma or chemotherapeutic

agents, such as fluorouracil. Primary acquired nasolacrimal duct obstruction (PANDO) develops most commonly in the tract of lacrimal sac and duct. In 1967, Dalgleish et al. reported that the incidence of nasolacrimal pathway disorders in the population over age 40 years was 10 - 14 %, but at the age of 90 years, it was 40 % [2]. Forty years later, Woog et al. published a study concerning the epidemiology of acquired symptomatic lacrimal obstruction and showed that the most common form of acquired symptomatic lacrimal obstruction is PANDO, occurring with an annual incidence rate of 0.02 % [3]. The etiology of PANDO is unknown. Several predisposing factors have been suggested. According to the available research data, no evidence was found to support the role of viral infection (HSV1, HSV2, HPV), eye makeup, and sex hormones in the pathogenesis of PANDO. There is no evidence that abnormal pathology was found in lacrimal sac biopsy of patients with PANDO [4].

Narrowing of the bony nasolacrimal canal is considered one of the significant factors in developing primary acquired nasolacrimal duct obstruction [5, 6]. The system that secretes and drains tears into the nasal cavity consists of the lacrimal gland, and the upper and the lower lacrimal pathways. The upper lacrimal pathway consists of the puncta and lacrimal canaliculi, whereas the lower lacrimal pathway consists of the lacrimal sac and nasolacrimal duct. The nasolacrimal duct includes a bony part. The anterior part of the bony pathway is formed by the frontal process of the maxilla and posteriorly by the lacrimal bone [7]. There is a dearth of published quantitative data on the normal diameter of the bony nasolacrimal canal, but even fewer quantitative data have been published on the bony nasolacrimal canal dimensions in patients with epiphora caused by obstruction of the nasolacrimal duct system. Such narrowing may result in tear flow stagnation, debris accumulation, and mucosal adhesion in the nasolacrimal duct. Shigeta and co-workers 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 [1]. In their theory, the narrowness of the bony nasolacrimal canal and the acute angle between the bony nasolacrimal canal and the nasal floor in females may predispose to chronic inflammation of the nasolacrimal drainage system. A review of the literature shows that narrow passages are found more often in women and Caucasians, resulting in gender and racial differences in the PANDO incidence [5 - 11].

Moreover, knowing the orientation of the bony lacrimal passage is an essential factor for the success of lacrimal probing and intubation. In the most of the western literature lacrimal fossa inclines posterolaterally as a bony nasolacrimal canal. But some recent studies found that it courses from the entrance to the bony nasolacrimal canal vary among different individuals. A false passage may occasionally occur during lacrimal probing and intubation at the junction between the lacrimal sac fossa and the bony nasolacrimal canal. The knowledge of the morphometry of the lacrimal drainage system enables the ophthalmologist to plan an intervention on the lacrimal drainage system precisely and avoid unnecessary manipulations. PANDO can be successfully treated with dacryocystorhinostomy, a surgical procedure during which an opening is made between the lacrimal sac and the nose proximal to the obstruction of the drainage system. Today, such obstructions are increasingly being treated with balloon dacryocystoplasty, which is generally successful, depending on appropriate patient selection, or with stent placement.

On the other hand, some studies witnessed no significant link between bony nasolacrimal canal dimensions and PANDO [12]. According to Bulbul et al. the mean bony nasolacrimal canal minimum transverse diameters were not statistically different for the PANDO side and non-PANDO side groups [5]. Although Janssen et al. found narrower bony nasolacrimal canal minimum transverse diameters in women than men in the control group, there was no difference between genders in the patient group [8].

These varying results prevent reaching a conclusive determination. Moreover, the etiology of bony nasolacrimal canal narrowing has primarily been investigated in normal populations. Thus, these findings cannot be used to draw any conclusions about the anatomy of patients with nasolacrimal duct obstruction. The purpose of the study was to determine the morphometric differences of bony nasolacrimal canals of unilateral PANDO patients, comparing PANDO and non-PANDO sides and a control group, using CT scans.

Materials and Methods

Study design

We used a hospital-based, retrospective, case-control design for the study. All patient data and CT scans were obtained from the Department of Ophthalmology, Mongolian National University of

Medical Sciences and Oculoplastic clinic, Ulaanbaatar, Mongolia.

Study population

A power analysis determined that a sample size of 292 patients was required to achieve 80 percent power at a 5 percent significance level. Consequently, 292 consecutive patients > 16 years of age (146 male and 146 females; male-to-female ratio = 1: 1) with unilateral PANDO, were compared to 292 control patients (146 male and 146 females; male-to-female ratio = 1:1) over 16 years of age. The patients' orbital CT scans were analyzed between January 31, 2020, and January 31, 2021, at the Department of Anatomy and Department of Ophthalmology, Mongolian National University of Medical Sciences University and the university's affiliated oculoplastic eye clinic.

Two groups of patients were enrolled in our study. The patients with unilateral PANDO were diagnosed by patient history, lacrimal irrigation, probing, and imaging. CT was routinely performed in patients with PANDO to identify nasal pathology and to rule out any secondary nasolacrimal duct obstruction. The CT also showed the nasolacrimal duct of the non-PANDO side, so the dimensions of their canals could be compared. Patients with pre-sac nasolacrimal duct obstruction, abnormal eyelid position, history of lacrimal surgery, loss to follow-up within 6 months, facial bone fracture, history of nasal and paranasal sinus surgery, history of brain surgery, facial palsy and allergic rhinitis were excluded from this study.

The control group was similarly aged blunt ocular trauma patients with no bony nasolacrimal fracture and a normal lacrimal irrigation test or patients with a CT scan for some other indication without PANDO disease. They were selected from among patients admitted to the Oculoplastic Clinic without any documented epiphora complaint in the hospital patient database records.

The lacrimal canals were categorized as 1) the affected side in patients with unilateral PANDO, 2) the unaffected side with unilateral PANDO, and 3) participants without PANDO.

Inclusion criteria

Case group - Unilateral PANDO (ICD-10-CM diagnosis code: H04.559); Control group - No PANDO disease.

Exclusion criteria

Patients were excluded if they had bilateral PANDO, pre-sac nasolacrimal duct obstruction, eyelid malposition, history of lacrimal surgery, were lost to follow-up within 6 months, had a facial bone fracture, history of nasal and paranasal sinus surgery, history of brain surgery, facial palsy and allergic rhinitis. The exclusion criteria for the control group were the same as for the PANDO group.

Clinical examination

The diagnosis of PANDO in patients who presented to the ophthalmology clinic with excessive eye watering was confirmed by a blockage on the lacrimal irrigation test at the time of their consultation the Oculoplastic Clinic, Mongolian National University of Medical Sciences.

Morphometric measurements

We measured morphometry of bony nasolacrimal duct, including the nasolacrimal canal length, transverse diameter, anteroposterior diameter, distal nasolacrimal canal diameter, nasolacrimal canal volume, sagittal plane orientation angle of the nasolacrimal canal and lacrimal sac and nasolacrimal canal angle (Figure 1, 2). Bony nasolacrimal canals in unilateral PANDO patients were divided into two groups, the PANDO side and non-PANDO side. The control group's right and left bony nasolacrimal canals were studied as the controls. All patients under study had thin section 1.5 mm CT sections obtained in the transverse, axial and coronal planes throughout the orbits and nasal/paranasal structures (Somatom Sensation; Siemens firm, München, Germany). The images were analyzed with a digital image workstation (Materialise Mimics 10.01, Leuven, Belgium; Osirix, Bernex, Switzerland). Two ophthalmologists performed measurements separately in the first 40 patients. Interobserver reliability was determined with the intraclass correlation coefficient (ICC). Subsequently, one ophthalmologist performed the rest of the measurements in patients.

Statistical analysis

The normality of the continuous variables was assessed by the Kolmogorov-Smirnov test and distribution histograms. Categorical variables were presented as frequencies and percentages. The categorical variables were compared using a χ^2 test. Continuous variables were presented as mean ± standard deviation (SD). Comparison of two groups of a continuous variable was accomplished using t-tests. Comparison of more

than two groups of a continuous variable was accomplished using one-way ANOVA with Tukey multiple posthoc comparisons. Statistical significance was defined as $p < 0.05$. The analyses were performed using Stata version 11.2. (Stata Corp, College Station, TX, USA).

Ethical statement

The study was approved by the Research Ethics Committee of the Mongolian National University of Medical Sciences on March 01, 2020 (No. 2020/3-01). All patients signed an informed consent form before clinical examination and morphometric measurement.

Results

Five hundred eighty-four participants were enrolled in this study (292 PANDO, 292 controls; ratio = 1:1). The average age was 63.1 ± 11.3 years for PANDO patients and 62.9 ± 12.6 for the control patients (Table 1).

Age and gender were not significantly different between patients and control groups ($p = 0.31$ and 0.41, respectively). The intraclass correlation coefficient was over 0.86 for each measured parameter indicating excellent agreement between the two observers. In the control group, right and left side measurements were not significantly different ($p > 0.41$); therefore, both eyes were accepted as control eyes.

Table 1. Patient's demographic data.

Variables	Control Group (n = 292)	PANDO Patients (n = 292)	Total (n = 584)	*p-value
	Mean ± SD	Mean ± SD	Mean ± SD	
Age (years)	62.40 ± 13.41	63.10 ± 11.30	62.75 ± 12.35	0.871[b]
Male	60.26 ± 8.79	62.09 ± 10.66	61.17 ± 9.73	
Female	64.44 ± 15.32	64.11 ± 11.96	64.28 ± 13.64	
p-value	0.314[b]	0.159[b]		
Gender	N (%)	N (%)	N (%)	
Male	80 (27.3)	73 (25)	153 (26.2)	0.091[a]
Female	212 (72.7)	219 (75)	431 (73.8)	

*No statistical significance using a [a]χ^2 test or [b]t-test. No significant age difference between genders in the case and control groups.

Table 2. Bony nasolacrimal canal morphometric measurements in PANDO side, non-PANDO side and control groups.

Morphometric measurements	Control (n = 292)	PANDO (n = 292)	Non-PANDO (n = 292)	p-value*
Bony nasolacrimal canal length (mm)	10.66 ± 1.76	10.50 ± 1.65	10.63 ± 1.55	0.242
Transverse diameter (mm)[a]	4.69 ± 1.61	4.36 ± 1.59	4.43 ± 1.83	0.016
Anteroposterior diameter (mm)	6.52 ± 1.15	6.43 ± 1.31	6.45 ± 1.40	0.214
Minimum nasolacrimal canal (mm)[b]	3.88 ± 1.16	3.45 ± 1.59	3.68 ± 1.67	0.012
Distal end of nasolacrimal canal (mm)[c]	4.90 ± 1.45	4.26 ± 1.18	4.27 ± 1.36	0.011
Volume of nasolacrimal canal (mm^3)	3.34 ± 1.72	3.41 ± 1.78	3.39 ± 0.91	0.143
Orientation angle in sagittal plane of nasolacrimal canal (degree)	74.81 ± 7.58	77.67 ± 7.11	80.82 ± 8.68	0.103
Lacrimal sac and nasolacrimal canal angle (degree)	18.64 ± 6.62	20.39 ± 5.60	19.13 ± 5.07	0.259

*ANOVA test; multiple comparisons. [a]Control vs PANDO, $p = 0.012$; [a]Control vs non-PANDO side, $p = 0.027$. The transverse diameter was smaller in PANDO and non-PANDO groups than the control group. [b]Control vs PANDO, $p = 0.011$; [a]Control vs non-PANDO side, $p = 0.012$; The minimum nasolacrimal canal diameter was smaller in PANDO and non-PANDO groups than in the control group.[c]Control vs PANDO side, $p = 0.009$, [c]Control vs non-PANDO side, $p = 0.011$. The distal nasolacrimal canal diameter was smaller in PANDO and non-PANDO side than the control group. PANDO - Primary Acquired Nasolacrimal Duct Obstruction.

The mean bony nasolacrimal canal length for the PANDO side, non-PANDO side, and the control group were 10.50 ± 1.65, 10.63 ± 1.55 and 10.66 ± 1.76 mm, respectively, and there was no difference between groups (Table 2). The measured diameters for the PANDO and non-PANDO groups were significantly narrower than controls in (p = 0.027 and 0.012), minimum nasolacrimal canal (p = 0.012 and 0.011) and distal (p = 0.009 and 0.011). The entrance bony nasolacrimal canal transverse diameter was 4.36 ± 1.59 mm in the PANDO side, 4.43 ± 1.83 mm in the non-PANDO side and 4.69 ± 1.61 mm in the control group and there was a statistical difference between groups (p = 0.016).

The minimum bony nasolacrimal canals transverse diameter in the PANDO side, non-PANDO side, and control groups were 3.67 ± 1.96, 3.98 ± 2.01, 4.03 ± 1.12 mm, respectively, and these were statistically different between groups (p < 0.001). The distal bony nasolacrimal canal transverse diameter in PANDO side, non-PANDO side, and control group were 4.39 ± 1.21, 4.33 ± 1.32, 5.11 ± 1.25 mm (p < 0.001). The bony nasolacrimal canal volume in the PANDO side, non-PANDO side,

Table 3. Nasolacrimal canal coronal orientation in the control, PANDO side and non-PANDO side groups.

	Cases (n = 292)			
Types	**Control N (%)**	**PANDO N (%)**	**Non-PANDO sid N (%)**	**p-value[a]**
Inward type	193 (66.1)	173 (59.2)	179 (61.3)	0.631
Outward type	99 (33.9)	119 (40.8)	113 (32.7)	0.453

[a]One-way ANOVA test with posthoc Tukey test showed that both PANDO and non-PANDO groups were not significantly different compared to controls. PANDO - Primary Acquired Nasolacrimal Duct Obstruction.

Table 4. A summary of measurements and comparison of women in the groups.

Morphometric measurements	Control	PANDO side	Non-PANDO side	p-value*
Nasolacrimal canal length (mm)	10.11± 1.93	9.81 ± 1.32	9.92 ± 1.09	0.413
Transverse diameter (mm)[a]	4.59 ± 2.04	4.25 ± 1.75	4.31 ± 1.65	0.038
Anteroposterior diameter (mm)	6.40 ± 1.34	6.33 ± 1.41	6.25 ± 1.33	0.231
Minimum nasolacrimal canal (mm)[b]	3.73 ± 1.21	3.23 ± 1.23	3.38 ± 1.34	0.017
Distal nasolacrimal canal (mm)	4.69 ± 1.66	4.13 ± 1.16	4.21 ± 1.41	0.082
Volume of nasolacrimal canal (mm^3)	3.17 ± 2.23	3.21 ± 1.63	3.29 ± 0.84	0.221
Orientation angle in sagittal plane of nasolacrimal canal (degree)	75.11 ± 8.02	79.13 ±7.67	82.13 ± 9.21	0.192
Lacrimal sac and nasolacrimal canal angle (degree)	19.21 ± 7.22	22.86 ± 6.53	20.13 ± 4.19	0.516

*ANOVA test; multiple comparison. [a]Control vs PANDO, p = 0.026; Control vs non-PANDO side, p = 0.041. The transverse diameter of nasolacrimal canal was narrower in PANDO and non-PANDO side groups than in the control group. [b] Control vs PANDO, p = 0.016; Control vs non-PANDO side, p = 0.023. The minimum NLC was smaller in PANDO and non-PANDO side groups than in the control group. PANDO = Primary acquired nasolacrimal duct obstruction.

Table 5. A summary of measurements and comparison between men among the groups.

Morphometric measurements	Control	PANDO	Non-PANDO side	p-value*
Nasolacrimal canal length (mm)	11.21 ± 1.60	11.19±1.98	11.34 ±2.02	0.413
Transverse diameter (mm)	4.79 ± 1.18	4.56± 2.02	4.47± 1.44	0.069
Anteroposterior diameter (mm)	6.64 ± 1.29	6.53 ± 1.22	6.62 ± 1.48	0.231
Minimum nasolacrimal canal (mm)	4.03 ± 1.12	3.67 ± 1.96	3.98 ± 2.01	0.059
Distal end nasolacrimal canal (mm)	5.11 ± 1.25	4.39 ± 1.21	4.33± 1.32	0.082
Volume of nasolacrimal canal (mm^3)	3.52 ± 1.21	3.62± 1.93	3.49± 0.98	0.221
Orientation angle in sagittal plane of nasolacrimal canal (degree)	74.50 ± 7.15	76.21±6.54	79.52± 8.16	0.192
Lacrimal sac and nasolacrimal canal angle (degree)	18.07± 6.03	17.92±4.67	18.13± 5.96	0.516

* One way-ANOVA test.

and control group were 3.41 ± 1.78, 3.39 ± 0.91, 3.34 ± 1.72 mm^3 respectively and there was no difference between groups. The sagittal plane orientation angle of the nasolacrimal canal in the PANDO side, non-PANDO side, and control groups were 77.67 ± 7.11, 80.82 ± 8.68, 74.81 ± 7.58 degrees (p = 0.103). The lacrimal sac and nasolacrimal canal angle in the PANDO side, non-PANDO side, controls were 20.39 ± 5.60, 19.13 ± 5.07 and 18.64 ± 6.62 degrees (p = 0.259).

Regarding the bony nasolacrimal canal orientation type in the coronal plane, the numbers of inward and outward types for the PANDO side group were 196 (67.1 %) and 96 (32.9 %), respectively. For non-PANDO side numbers of inward and outward types were 189 (64.7 %) and 103 (35.4 %), respectively. Two hundred twenty-one (75.9 %) inward and 71 (24.1 %) outward types were detected in the control group (Table 3). There was no statistically significant difference in the frequency distributions of the PANDO side, non-PANDO side, and control group (p = 0.210).

The analysis of gender differences showed (Table 4, 5) that transverse diameter was narrower among women in the PANDO and non-PANDO side groups than the control group (p = 0.038). The minimum nasolacrimal canal was smaller among women in the PANDO and non-PANDO side groups than in the control group (p = 0.017).

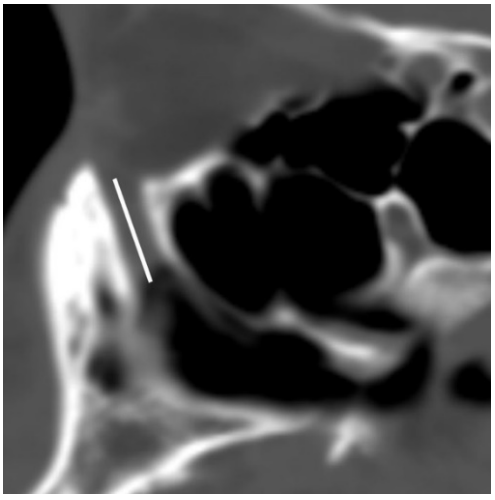

Figure 1. Sagittal CT scan image reveals bony nasolacrimal canal length (white line) measurement.

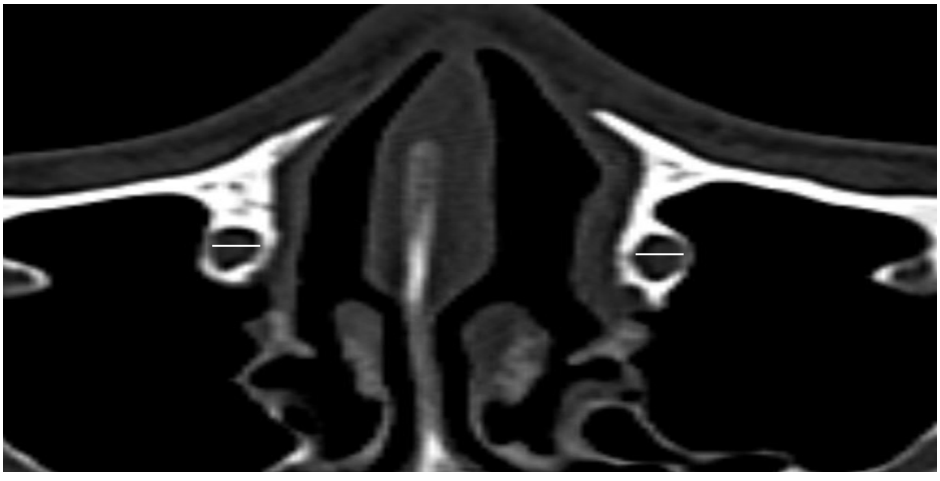

Figure 2. Axial CT scan image in bone window demonstrates bony nasolacrimal canal transverse diameter measurement (white lines).

Discussion

The bony nasolacrimal canal structure is thought to contribute to PANDO development with alterations in canal morphology resulting in tear flow resistance [5, 6]. A modification in the lumen diameter of the lacrimal passage affects tear flow resistance [13]. CT scan is the best imaging option for differentiating the contrast resolution between bony structures and surrounding soft tissues [9, 14].

Takahashi et al. assessed bony nasolacrimal canal narrowing between the affected and unaffected sides of the PANDO patients and their control group [12]. They measured the minimum bony nasolacrimal canal anteroposterior and transverse diameters. They found a mean bony nasolacrimal canal minimum transverse diameter of 5.09 ± 1.46 mm, 4.96 ± 1.15 mm, 4.80 ± 0.80 mm in the affected and unaffected sides of the PANDO patients and the control group, respectively. Additionally, there was no difference between groups in the bony nasolacrimal canal's minimum anteroposterior and transverse diameters. Even though the studies were designed similarly, the results differ from our study. Janssen et al. reported a mean bony nasolacrimal canal minimum transverse diameter of 3.0 mm (range 2 – 4.3 mm) in the PANDO group and of 3.5 mm (range, 1.5 – 6.3 mm) in the control group, a statistically significant difference [8]. Therefore, a narrower bony nasolacrimal canal transverse diameter was proposed as a predisposing factor for PANDO, as slight mucosal swelling can obstruct it. Our data support this hypothesis and it previous studies as well [15 - 19].

Estes et al. recently introduced bony nasolacrimal canal volume measurements in their study. It measured 0.411 ± 0.18 cm^3 for the PANDO patients and 0.380 ± 0.13 cm^3 control group ($p > 0.5$) [15]. Likewise, we found no significant group-wise differences in our study. Even though the bony nasolacrimal canal length has been measured in the normal population, it has not been yet measured in the PANDO patients. Ramey et al. measured a bony nasolacrimal canal length of 12.3 ± 2.5 mm in men and 10.8 ± 2.5 mm in women in their research performed among a healthy population [20]. Our study found evidence to support that the mean bony nasolacrimal canal length of the PANDO patients was indistinguishable from the control group and the healthy population values, similar to the findings of Ramey et al. [20]. Therefore, the length of the canal does not contribute to the development of PANDO.

A cadaveric study described relative lacrimal sac-bony nasolacrimal canal angle and bony nasolacrimal canal type in the coronal plane. The authors reported a mean relative lacrimal sac bony nasolacrimal canal angle of 11.8° with a range of 1 – 32° and found no statistical difference in the coronal type of bony nasolacrimal canal between genders [11]. We also concluded that bony nasolacrimal canal lengths, bony nasolacrimal canal coronal and sagittal orientations, and relative lacrimal sac-bony nasolacrimal canal angles were indistinguishable between groups, indicating they were not causative factors for PANDO.

We compared some of our study results with Enkhzaya and associates' study done among Mongolians [21]. Their study showed a nasolacrimal canal length of 11.50 ± 1.48 mm, anteroposterior diameter of 6.54 ± 1.02 mm, transverse diameter of 4.54 ± 0.91 mm, and saggital plane orientation angle of the nasolacrimal canal of 69.88 ± 7.93. These were not different from our findings.

Our results show that distal bony nasolacrimal canal transverse diameter at the level of Hasner's valve was indistinguishable for the PANDO side and non-PANDO side groups. Both were found to be much narrower than the control group. Drainage from the lacrimal system in the PANDO patients might suffer from a stagnation caused by a narrow distal bony nasolacrimal canal transverse diameter, increasing the potential effect of the bony nasolacrimal canal minimum transverse diameter. Apparently, even though a narrow bony nasolacrimal canal predisposes for duct occlusion, environmental factors or exposures, mucus plaques, descending or ascending infections, and dacryocystitis attacks determine the side of the duct involvement [5, 6]. Moreover, the narrower distal bony nasolacrimal canal transverse diameter detected in both the PANDO and non-PANDO sides of the unilateral PANDO patients compared with the control group in our study.

In most cases, women have been diagnosed with a primary acquired nasolacrimal duct obstruction. The previous studies found narrow bony nasolacrimal canal minimum transverse diameter in women from the non-diseased population. This anatomic characteristic was considered a key factor for PANDO development [12]. Although Janssen et al. found narrower bony nasolacrimal canal minimum transverse diameters in women than men in the control group, there was no difference between genders in the patient group [8]. Takahashi et al. found that female subjects also exhibited smaller transverse diameters at

the bony nasolacrimal canal entrance [11, 12]. Likewise, we found a narrower bony nasolacrimal canal transverse diameter in women than men on the PANDO side of patients.

Our study has some limitations. The study design was retrospective. A PANDO patient's unaffected may subsequently develop a primary acquired nasolacrimal duct obstruction in the future. This could adversely affect our research results. In the future, we will follow up the unilateral PANDO case group to see whether the unaffected side develops an obstruction.

Conclusions

Our study discovered a significantly smaller mean bony nasolacrimal canal minimum transverse diameter for both the PANDO and non-PANDO sides of the PANDO patients compared to control patients. This outcome supports the opinion that narrow bony nasolacrimal canal morphology may predispose PANDO development. Furthermore, narrower distal bony nasolacrimal canal transverse diameter detected in both the PANDO and non-PANDO sides of the unilateral PANDO patients, as compared with the controls, may increase the effect of a narrow bony nasolacrimal canal minimum transverse diameter. Despite such findings, no difference between the PANDO and the non-PANDO side of the unilateral PANDO patients and some commonality between the PANDO patients and control group suggests that a narrow bony nasolacrimal canal is not the sole factor.

Conflict of Interest

The authors declare that they have no conflict of interest concerning this study.

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