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Preliminary study on the correlation between primary lacrimal punctal stenosis and epiphora by using AS-OCT

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原发性泪点狭窄的前节 OCT 特征及其与溢泪相关性的初步研究

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摘要

目的:应用眼前节光学相干断层扫描(AS-OCT)对原发性泪点狭窄患者的泪点进行量化,并分析其与溢泪的相关性。

方法:横断面研究。共纳入 2020 年 9 月至 2021 年 1 月于解放军总医院第三医学中心泪器病中心就诊的 44 例(62 眼)原发性泪点狭窄伴溢泪的患者为观察组,对照组为 43 例(57 眼)健康志愿者。对所有受试者的下泪点进行 AS-OCT扫描,并对泪点图像进行量化,以观察其 AS-OCT 图像特征,测量参数包括泪点外径、泪点深度、泪点内残留泪液的液面直径及深度,根据以上参数计算泪点储备量及比率。

结果:1)符合正态分布的各测量参数用均数±标准差表示,结果如下,观察组:泪点外径 458.19±63.58μm、泪点内残留泪液的直径 200.34±84.69μm、泪点内残留泪液的深度 188.95±87.50μm、泪点储备比率 0.32±0.18;正常对照组各测量参数为:泪点外径 655.53±82.62μm、泪点内残留泪液的直径 230.26±107.02μm、泪点内残留泪液的深度 275.30±144.34μm、泪点储备比率0.46±0.23,观察组各参数均小于正常组($P<0.05$);2)不符合正态分布的参数数据则用中位数及四分位数表示,结果如下,观察组:泪点深度 265.50μm(四分位间距204.25-328.77)μm、泪点储备量 71.53μm(四分位间距 46.12-111.37)μm,对照组:泪点深度 468.76 μm(四分位间距 420.50-588.88)μm、泪点储备量 182.16μm(四分位间距 131.36-309.84)μm,观察组各参数数据均小于正常对照组($P<0.05$);3)观察组测量数据显示,溢泪程度与泪点外径呈负相关(相关系数 $r=-0.448$, $P<0.05$)、与泪点内残留泪液的深度呈正相关(相关系数 $r=0.335$, $P<0.05$)、与泪点储备量及其比率呈负相关(相关系数 $r=-0.520$、-0.566, $P<0.05$)。

结论:AS-OCT 的使用可以帮助提高对泪点形态的认知;泪点内残留泪液的深度以及泪点外径的大小与溢泪相关;原发性泪点狭窄者中泪点储备泪液的潜在能力越强,溢泪程度越弱,且泪点外径小者相对于泪点外径大者更易出现溢泪症状。

关键词:泪点狭窄;原发性;溢泪;光学相干断层扫描

Abstract

• AIM: To quantify the lacrimal punctum using anterior segment optical coherence tomography (AS-OCT) and analyze the correlation between the epiphora and primary punctal stenosis.

• METHODS: A cross-sectional study. There were 43 healthy volunteers (57 eyes) and 44 patients (62 eyes) with primary lacrimal punctal stenosis and epiphora enrolled in the Lacrimal Center of the Third Medical Center of PLA General Hospital from September 2020 to January 2021. The inferior punctum of all subjects were scanned by AS-OCT, and the images were quantified in order to observe the AS-OCT image features. The outer punctal diameter, punctal depth, tear well diameter and tear well depth were all measured simultaneously. The inferior punctum's punctal reserve and punctal reserve ratio were estimated according to the available parameter data.

• RESULTS: 1) The measured parameters conforming to normal distribution were expressed as mean ± standard deviation. The observation group's outer punctal diameter, tear well diameter, tear well depth, and punctal reserve ratio were 458.19±63.58μm, 200.34±84.69μm, 188.95±87.50μm and 0.32±0.18, respectively, while the control group's outer punctal diameter, tear well diameter, tear well depth and punctal reserve ratio were 655.53±82.62μm, 230.26±107.02μm, 275.30±144.34μm, 0.46±0.23, respectively. The parameters in observation group were all lower than those of control group ($P<0.05$); 2) Parameter data that did not conform to normal distribution were expressed as medians and quartiles, and the results were as follows: the punctal depth in the observation group was 265.50μm (interquartile range 204.25-328.77) μm and the punctal reserve was 71.53μm (interquartile range 46.12-111.37) μm, respectively, while the punctal depth in the control group was 468.76μm (interquartile range 420.50-588.88) μm and the punctal reserve was 182.16μm (interquartile range 131.36-309.84) μm. This difference was statistically significant ($P<0.05$); 3) In the observation group, there was a negative correlation between the epiphora and the outer punctal diameter ($r=-0.448$, $P<0.05$), a positive correlation between the epiphora and tear well depth ($r=0.335$, $P<0.05$), and a negative correlation between the epiphora and the punctal reserve and punctal reserve ratio coefficient ($r=-0.520$, -0.566, $P<0.05$).

• CONCLUSION: The AS-OCT can aid in enhancing punctal morphology cognition; The outer punctal diameter and tear well depth are related to the epiphora; The primary punctal stenosis patients with smaller outer punctal diameters are more likely to have the symptom of epiphora, and in patients with punctal stenosis, the greater the potential capacity of the punctum to hold tears, the lesser the degree of epiphora.

• KEYWORDS: lacrimal punctal stenosis; primary; epiphora; optical coherence tomography
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INTRODUCTION

The lacrimal punctum is the opening of the lacrimal duct on the margin of each eyelid near the medial commissure, a round or slightly oval pinhole structure with a diameter of around 0.3mm[1]. It is situated above the lacrimal papilla. About 80% of tears enter the nasal cavity through the inferior lacrimal punctum, which is located next to the semilunar fold and bulbar conjunctiva and serves as the starting point of the lacrimal duct drainage system[2]. There are three types of lacrimal punctal stenosis: primary, congenital, and acquired[3]. Ophthalmologists should pay more attention to primary lacrimal punctal stenosis since it might result in variable degrees of epiphora, which is the predominant clinical symptom of patients. Currently, anterior segment optical coherence tomography (AS-OCT) has been used to assess the patency and position of lacrimal punctal plugs implanted for treating punctal stenosis[4], but there are few publications that use it to examine the correlation between the stenosis of the lacrimal puncta and the presence of epiphora. The objective of this study was to scan the individuals' inferior puncta and examine the OCT properties while utilizing OCT imaging qualities that are non-contact, non-invasive, simple to achieve, high resolution, and good reproducibility[5]. To assess the relationship between each parameter and the epiphora, the acquired images were quantified. The findings are listed below.

SUBJECTS AND METHODS

The subjects had basic data including age, sex, family history, trauma history, systemic history, and ocular history recorded. After slit-lamp biomicroscopy, lacrimal punctal OCT examination, and, if necessary, three-plane reconstruction of CT dacryocystography based on the trend of the nasolacrimal canal (CT-DCG-TPR-BTNC), the lacrimal duct-related examination was carried out.

Research Subjects　There were 43 normal volunteers (57 eyes) and 44 patients (62 eyes) with epiphora and primary lacrimal punctal stenosis enrolled in the Senior Department of Ophthalmology at the Chinese PLA General Hospital. In this study, 16 male (21 eyes) and 28 female (41 eyes) were participants, while the control group consisted of 14 male (18 eyes) and 29 female (39 eyes). The inclusion criteria aged from 18 to 65 years old, lacrimal punctum size using slit-lamp biomicroscopy and epiphora as the symptom. The study followed the Helsinki Declaration and was approved by the Ethics Committee of the PLA General Hospital. All volunteers signed the informed consent.

Slit-lamp Biomicroscopy　All the cases were examined to observe the size of lacrimal punctum with slit-lamp biomicroscopy preliminarily.

OCT Examination　Choose the high-definition anterior segment 5-line scanning mode with a 3mm length, a 0° scanning angle, and a 0.25mm scanning line spacing. The patient maintains a 20-degree forward inclination of the head and face while resting the forehead and jaw on the corresponding supports. In order to push the eyelid slightly outward and to turn the inferior punctum roughly 60°-70° outward, the operator gently presses the eyelid with a cotton swab from directly below the inferior lacrimal punctum. Ask the subject to maintain the position while you make sure the lacrimal punctum is as vertically exposed to the OCT scanning light source axis as you can and attempt to capture the punctum's initial opening state for scanning. The same operator performs each inspection.

Lacrimal Duct Irrigation　This procedure was utilized on patients who had already had ophthalmologic tests using a

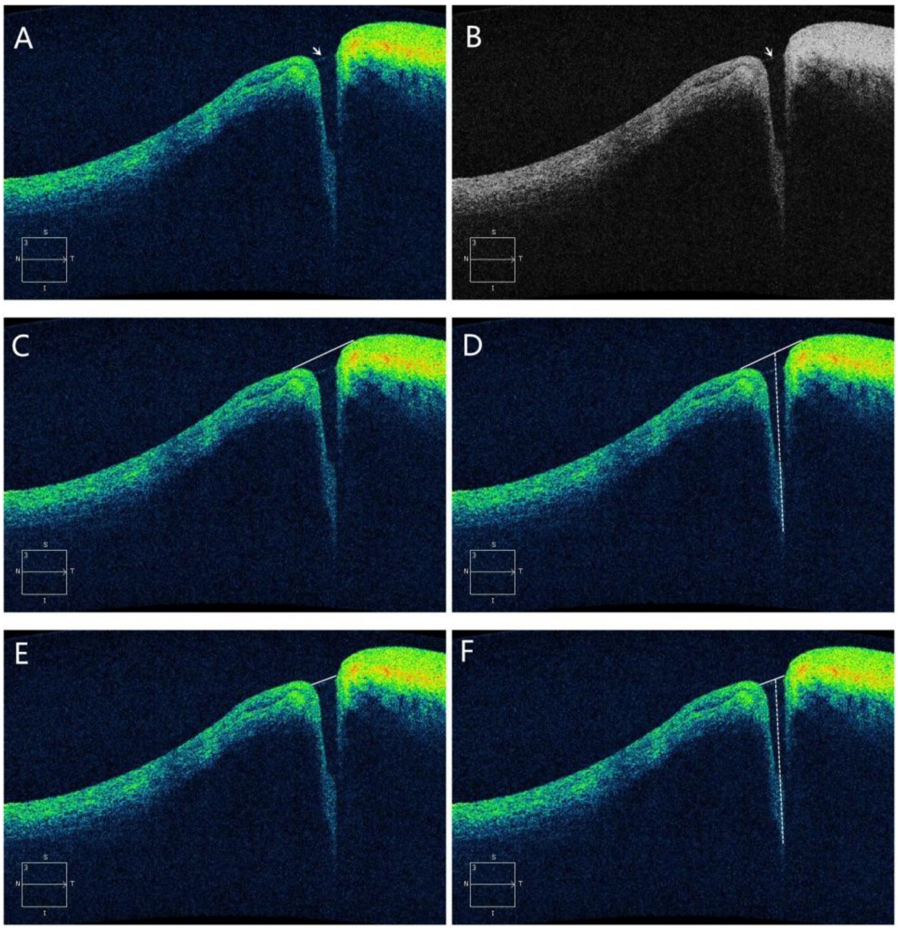

Figure 1　A and B: A typical inferior lacrimal punctum in pseudo-color and in grayscale, respectively, and the white arrows in both figures indicate the liquid level. C: The distance between the highest points of the punctal papilla is known as the outer punctal diameter. D: The height from the outer punctal diameter tangent to the bottom of the punctum is known as the punctal depth. E and F: The tear well's depth and diameter, respectively.

slit-lamp biomicroscope and an AS-OCT to treat epiphora brought on by stenosis or obstruction in areas other than the lacrimal punctum of the lacrimal duct.

Image Measurement　Both grayscale and pseudo-color images were gathered. The measurement parameters include the outer punctal diameter, punctal depth, tear well diameter, and tear well depth (Figure 1). From these measurements, one can calculate the punctal reserve (the difference between punctal depth and tear well depth) and PR ratio (PR to the punctal depth), which respectively, represent the punctum's remaining space and its capacity to store tears.

A pool of standing tears in the lacrimal punctum is known as the tear well. Tear well depth is the distance from the surface of the tear well to the bottom of the lacrimal punctum, while tear well diameter is the length of the tear well's surface[5].

Statistical Analysis　The normality test and the homogeneity test of variance were carried out before comparing the two groups using SPSS24.0 statistical software. The measurement results were expressed as mean standard deviation ($\bar{x}\pm s$) and the age, tear well depth, tear well width, and outer diameter of the lacrimal punctum of the two groups were all in a normal distribution. Independent sample t-tests were used to determine if the variances were homogeneous and uniform, respectively. Punctal depth and PR were expressed as median and quartile in the two groups and did not follow a normal distribution, the difference was statistically significant ($P<0.05$).

RESULTS

The study demonstrated that the wall of the inferior lacrimal punctum in the control group was typically smooth and regular in shape, but the patients' walls were less regular and had altered interior morphology (as shown in Figure 2).

All variables in the observation group, with the exception of the tear well diameter, were statistically significant when compared to the control group (as shown in Table 1 and Table 2).

The observation group's parameter analysis (as shown in Table 3).

The age was positively connected with lacrimal well diameter, negatively correlated with PR and PR ratio, and did not significantly differ from other characteristics.

There was no statistical difference between the epiphora and the other measures, however there was a negative correlation between the epiphora and the outer punctal diameter, PR, and PR ratio and a positive correlation with the tears well diameter.

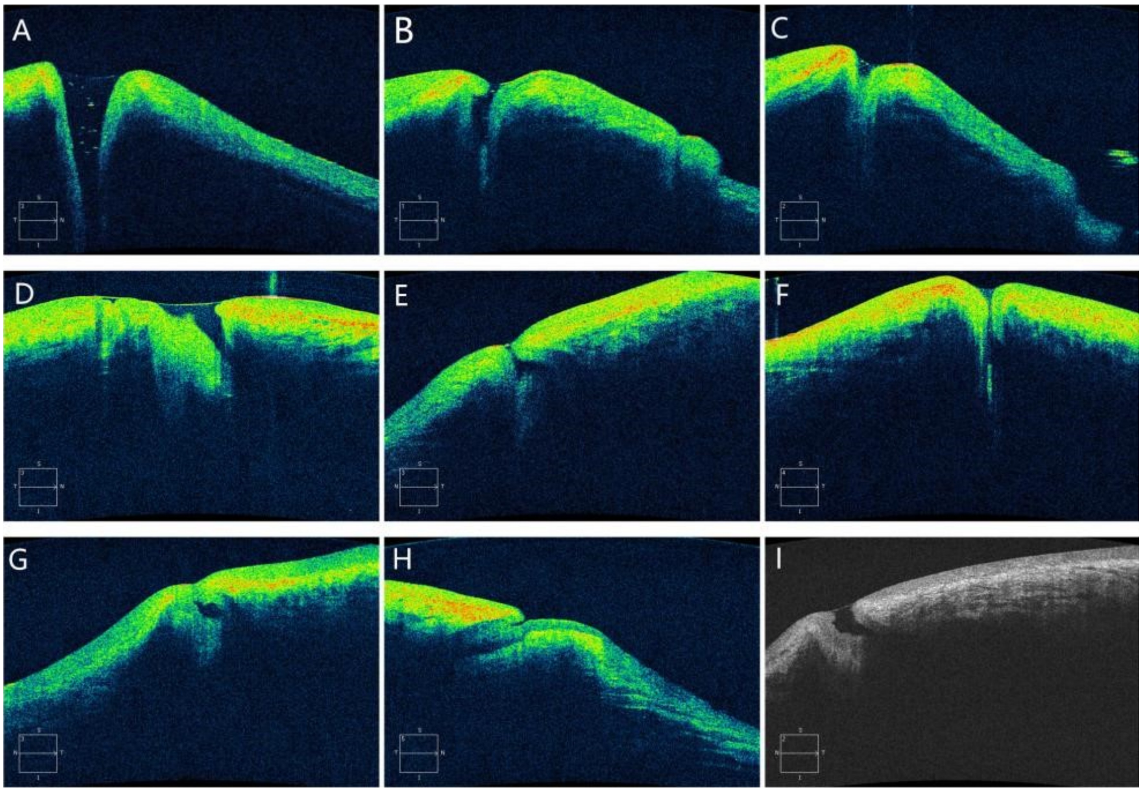

Figure 2 A: A normal inferior lacrimal punctum, which just like shape "V"; B-I: All the primary lacrimal punctal stenosis for different shapes.

Table 1 Comparison of parameters that conform to a normal distribution

Parameters	the observation group	the control group	T	P
outer punctal diameter($\bar{x}\pm s$, μm)	458.19±63.58	655.53±82.62	14.456	0.000[a]
tear well diameter ($\bar{x}\pm s$, μm)	200.34±84.69	230.26±107.02	1.698	0.092
tear well depth ($\bar{x}\pm s$, μm)	188.95±87.50	275.30±144.34	3.904	0.000[a]
PR ratio	0.32±0.18	0.46±0.23	3.701	0.000[a]

[a]indicates $P<0.05$, and there was a statistical difference between the two groups.

Table 2 Comparison of parameters that conform to a non-normal distribution

Parameters	the observation group	the control group	Z	P
punctal depth (μm)	265.50 (204.25, 328.77)	468.76 (420.50, 588.88)	8.293	0.000[a]
PR	71.53 (46.12, 111.37)	182.16 (131.36, 309.84)	7.179	0.000[a]

[a]indicates $P<0.05$, and there was a statistical difference between the two groups.

Table 3 Correlation of age, epiphora and parameters in the observation group

Parameters	age		Epiphora	
	R	P	R	P
punctal depth (μm)	0.098	0.449	0.103	0.426
tears well diameter(μm)	0.391	0.002[a]	0.093	0.474
tears well depth(μm)	0.080	0.535	0.335	0.008[a]
PR	0.346	0.006[a]	0.520	0.000[a]
PR ratio	0.252	0.048[a]	0.566	0.001[a]

[a]indicates $P<0.05$, and there was a statistical difference between the two groups.

DISCUSSION

The lacrimal punctum, which is open and naked on the surface of the palpebral conjunctiva, is the entry of the tear excretory system to the eye[6]. It resembles the mouth of a well. Epiphora is frequently brought on by lacrimal punctal stenosis, both primary and acquired. Primary lacrimal punctal stenosis is only infrequently recorded in the literature[7-8], whereas the latter is primarily brought on by trauma, inflammation, tumors, radiotherapy, and chemotherapy, *etc*. Jang *et al*'s[3] histological analysis of 38 patients' primary lacrimal punctal stenosis suggested that it was caused by the structure's degenerative alterations or by acute inflammation, but they did not go into great detail about the morphology. Slit-lamp biomicroscopy, three-plane reconstruction of CT dacryocystography based on the trend of the nasolacrimal canal (CT-DCG-TPR-BTNC), ultrasound biomicroscopy (UBM)[9-11], OCT[12-13], *etc*. are currently the main non-invasive imaging examinations used to examine the proximal lacrimal drainage system (PLDS), while UBM is unable to detect the lacrimal punctum and CT examination showed radiation. OCT is therefore very important for examining and structurally analyzing the lacrimal punctum, and there have previously been various investigations on this[14-15].

There were 44 patients with primary lacrimal punctal stenosis and 43 healthy volunteers chosen as the study's research subjects based on our earlier work[16]. Currently, measurements for OCT are published for punctum width, outer punctal diameter, inner and maximum punctum diameters, exterior and internal punctum sizes, epithelium thickness, tear well diameter, and punctal depth[5]. In this investigation, measurements of the commonly reported indicators outer punctal diameter, punctal depth, tear well diameter, and tear well depth were made. The PR and PR ratio were then computed using the above data.

The patients' outer punctal diameter, which was measured at (458.1±963.58) μm and had a negative correlation with the epiphora, was noted. The mean tear well depth in the patients was 188.95±87.50, which was lower than that in the healthy subjects and strongly linked with the epiphora. In other words, the two signs mentioned above are both connected to the epiphora.

As previously discussed, the PR serves as an indicator for remaining space available in the lacrimal punctum, and the PR ratio, defined as the PR to punctal depth ratio, was also put out by Sung *et al*[17] as a way to describe the storage capacity of tears. Our research revealed that the PR and PR ratio in the patients were lower than those in the control group, indicating that the patients may have had less capability for storing tears. The PR ratio of the patients was documented to be 0.32±0.18 and was negatively correlated with the degree of epiphora, indicating that the more tears could potentially be stored, the less epiphora there would be. It was also found to be inversely connected with age, and it might be connected to the lacrimal punctum's age-related fibrosis and other degenerative changes, which, as was previously indicated, affect tear storage capacity. In addition to being connected to the lacrimal sac's negative pressure, the punctum's tear storage capacity and space are also important factors in its tear drainage function.

In summary, OCT offers a more accurate assessment of the lacrimal punctum than slit-lamp biomicroscopy[18]. And the preliminary research on OCT for pre-punctoplasty and post-punctoplasty evaluation has been reported[19-21]. The results of our investigation showed a correlation between the tear well depth andouter punctal diameter and the epiphora, establishing the groundwork for subsequent applications in the analysis and recognition of epiphora.

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