• Clinical Research •

Diagnosis of lacrimal punctum lesions using optical coherence tomography: a preliminary study

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Abstract

● **AIM:** To study the imaging characteristics of lacrimal punctum lesion with optical coherence tomography (OCT), and provide imaging basis for the diagnosis and treatment of lacrimal punctum diseases.

● **METHODS:** A total of 25 patients (28 eyes) with epiphora and lacrimal puncta lesions were enrolled. Lacrimal puncta lesions included: punctum membrane obstruction in 7 cases (9 eyes), punctum agenesis in 1 case (1 eye), a mass protruded from the punctum in 1 case (1 eye), slit puncta in 1 case (1 eye), peri-puncta mass in 2 cases (2 eyes), chronic dacryocystitis in 4 cases (4 eyes), and primary puncta stenosis in 9 cases (10 eyes; 3 eyes mild, 4 eyes moderate and 3 eyes severe). All patients were examined by slit lamp microscopy and OCT to observe the morphological characteristics of abnormal punctum.

● **RESULTS:** Two types of complete membrane obstruction and incomplete membrane obstruction of puncta were observed in OCT images of 7 patients. No lacrimal punctum and lacrimal canalicular cavity were found in 1 case with punctum agenesis. OCT images showed that a narrow lumen remained in the lacrimal puncta in 1 patient with a mass protruded from the punctum. OCT of punctum in a patient with slit punctum after stent placement showed stent and abnormal lacrimal structure. No abnormal intraluminal structure was found in 2 cases of peri-puncta mass after OCT scan, and the lacunar space was narrower than that of the contralateral eye. OCT of puncta in 4 patients with chronic dacryocystitis showed that pus floated in tear with lump-like medium-low reflex. In 9 patients with primary lacrimal puncta stenosis, OCT image could clearly show the changes of puncta lumen in different degrees and shapes.

● **CONCLUSION:** OCT is feasible for the examination of pathological punctum, and can provide imaging basis for the diagnosis and treatment of punctum disease.

● **KEYWORDS:** lacrimal punctum lesions; epiphora; optical coherence tomography; diagnosis

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INTRODUCTION

Lacrimal punctum lesion is one of the main causes of epiphora. So far, the diagnosis of it mainly depends on slit lamp microscopy, and there are a few reports on the imaging examination of lacrimal punctum lesion. Optical coherence tomography (OCT) is a new optical examination and diagnosis technology, which can perform non-contact and non-invasive tomographic imaging of the microscopic structure of living eye tissues. The ability to penetrate non-transparent tissues reaches a depth of 1.6 mm, and can effectively image shallow tissues[1-3]. Using slit lamp microscope to examine the punctum, usually only the surface structure of the punctum can be observed, and the result is not accurate enough. In recent years, ultrasound biomicroscope (UBM) has also been applied in lacrimal punctum and lacrimal canaliculus examination[4-5]. UBM can examine the structures inside and around the lacrimal punctum, but the probe of the instrument needs to contact the examination site of the patient, and the resolution of the obtained image is lower than that obtained by OCT examination. Up to now, there have been a few literatures reporting the application of OCT for puncta examination, and good results have been achieved[6]. Our team had completed the examination and measurement of normal Chinese adult punctum with OCT[7], but there is few literature report on OCT imaging characteristics of Chinese patients with puncta diseases. This study aims to provide more accurate imaging

basis for clinical diagnosis and treatment strategy formulation of puncta diseases by observing and analyzing the imaging characteristics of Chinese puncta diseases in OCT images.

SUBJECTS AND METHODS

Ethical Approval The study followed the Helsinki Declaration and was approved by the Ethics Committee of the Third Medical Center of the PLA General Hospital. All volunteers signed written informed consent.

Subjects Twenty-five patients (28 eyes) with epiphora and puncta lesions were enrolled in the Lacrimal Center of the Third Medical Center of the PLA General Hospital, including 7 cases (9 eyes) of puncta membrane closure, 1 case (1 eye) of puncta absence, 1 case (1 eye) of punctal mass protruded from the punctum, 1 case (1 eye) of puncta tear, 2 cases (2 eyes) of peri-puncta mass, 4 cases (4 eyes) of chronic dacryocystitis, 9 cases (10 eyes) of primary puncta stenosis (3 eyes of mild, 4 eyes of moderate and 3 eyes of severe degree). Excluding patients with acute or chronic canaliculitis, with other acute or chronic inflammation of eye, children, patients with systemic serious diseases and unwilling to participate in the study. The subjects' information including age, sex, occupation, family history, trauma history, systemic and ocular history were recorded. Lacrimal duct related examination was performed after slit lamp microscopy and puncta OCT examination.

Slit Lamp Microscope Examination The subject keeps the head and face tilted forward by 20°, puts the forehead and jaw on the forehead rest and jaw support respectively, and gently presses the eyelid with cotton swab from directly below the lower punctum to turn the eyelid slightly outward, and turns the lower punctum outward by about 60°-70°, so that the lower punctum is vertically exposed to light as far as possible, taking care not to turn the punctum outward excessively to prevent it from being deformed due to excessive pulling. The mobile phone camera is used to shoot the punctum image under the slit lamp microscope (Miwa S350-PR, Shanghai Miwa Precision Instrument Co., Ltd., China; Figure 1A).

Optical Coherence Tomography Examination High-definition anterior segment 5-line scanning mode of OCT (ZEISS Cirrus TM HD-OCT Model 4000, Germany) with scanning angle of 0°, length of 3 mm and scanning line spacing of 0.25 mm were selected. The above-mentioned body position was kept to evert the lacrimal punctum so that the lacrimal punctum is vertically exposed to the axis of OCT scanning light source as far as possible (Figure 1B), and the most open state of the lacrimal punctum for scanning was captured . All examinations are performed by the same operator, and each eye to be examined is scanned 3 times to select the clearest, widest and deepest image.

Image Analysis and Measurement OCT grayscale and pseudo-color images are collected simultaneously. All patients with lacrimal punctum lesions were analyzed including the lower lacrimal punctum OCT imaging of lacrimal punctum morphology, content properties and the surrounding tissue such as lacrimal duct, *etc*. Some literatures showed that OCT images displayed in gray scale were better than those displayed in pseudo color[8], so gray scale images are selected for the measurement data in this study.

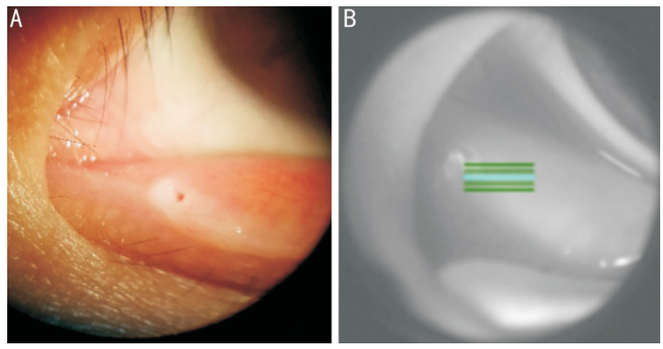

Figure 1 Incomplete punctum membrane closure A: Slit lamp microscope examination (16×); B: OCT examination.

Other parameters including the general morphology of lacrimal punctum observed under slit lamp microscope and irrigation of lacrimal duct were also collected. Irrigation lacrimal passage examination was performed after slit lamp microscopy and OCT examination.

RESULTS

In 7 patients with puncta membrane closure including complete puncta membrane closure (Figure 2A) and incomplete puncta membrane closure (Figure 2B) can be observed in OCT, and patients all have different degrees of epiphora. In OCT images of patients with puncta absence, no punctum and the lacrimal canal structure connected with the punctum were found, which may be combined with puncta absence (Figure 3). In OCT images of patients with lacrimal punctum tumor prolapse showed a narrow canal remained in the lacrimal punctum (Figure 4). No abnormal structure in the canal was found in OCT scanning, and the canal was narrower than the contralateral punctum. The OCT of patients with chronic dacryocystitis showed a massive hypoechoic floating in canal, which was considered as suppurative plug (Figure 5). OCT imaging of patients with primary punctum stenosis showed different degrees of stenosis (Figure 6). Punctum after lacrimal stent implantation can be seen as lacrimal stent and abnormal punctum structure.

DISCUSSION

The lacrimal punctum is the initial part of lacrimal passage, and the normal position and structure of the lacrimal punctum is the anatomical basis for the function of lacrimal drainage system. Hur *et al*[9] used slit lamp microscope to observe the morphology of puncta and classified them. In ophthalmology clinic, the traditional description of punctum is usually based on the subjective judgment of doctors after observing under

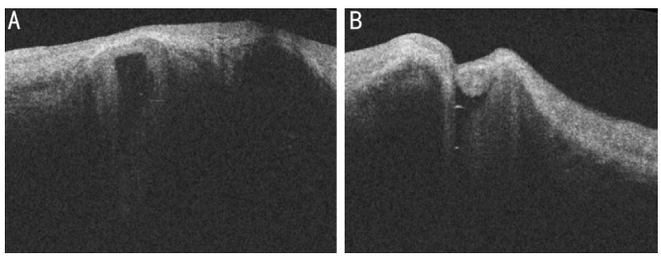

Figure 2 Puncta membrane closure in OCT A: Complete puncta membrane closure; B: Incomplete puncta membrane closure.

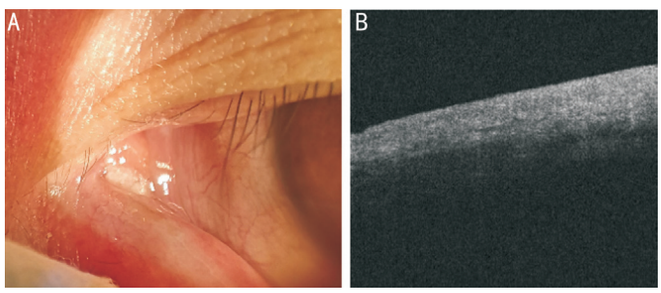

Figure 3 A punctum absence A: No punctum structure under slit lamp microscope; B: No punctum and lacrimal canal structure in OCT.

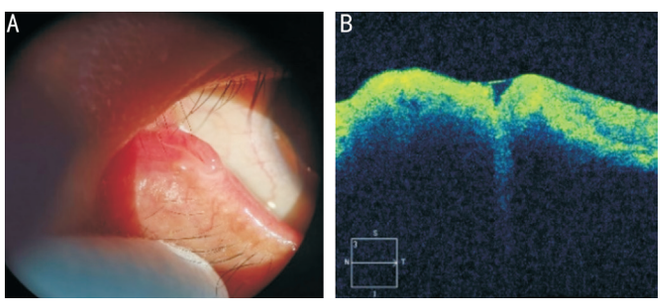

Figure 4 A patient with lacrimal punctum tumor A: Slit lamp microscope; B: The puncta mass in OCT imaging with a narrow cavity.

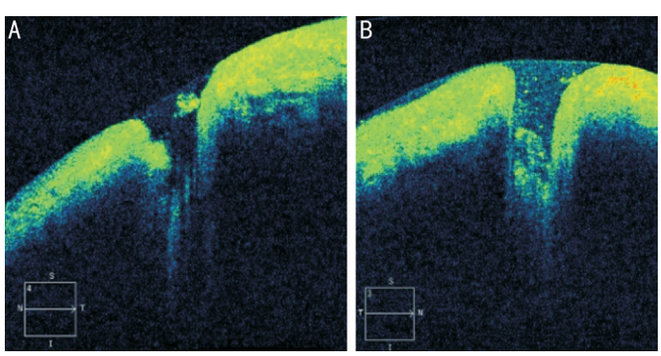

Figure 5 The OCT of patients with chronic dacryocystitis showed a massive hypoechoic floating in canal.

slit lamp microscope. Tao *et al*[5] used UBM to evaluate lacrimal punctum and canaliculus, but compared with OCT, UBM has lower resolution and the instrument needs to contact the patient during examination. In recent years, Wawrzynski *et al*[3] obtained high-resolution images of lacrimal punctum and proximal vertical canaliculus using OCT, which proved the feasibility of OCT in evaluating lacrimal drainage system. Subsequently, scholars have successively carried

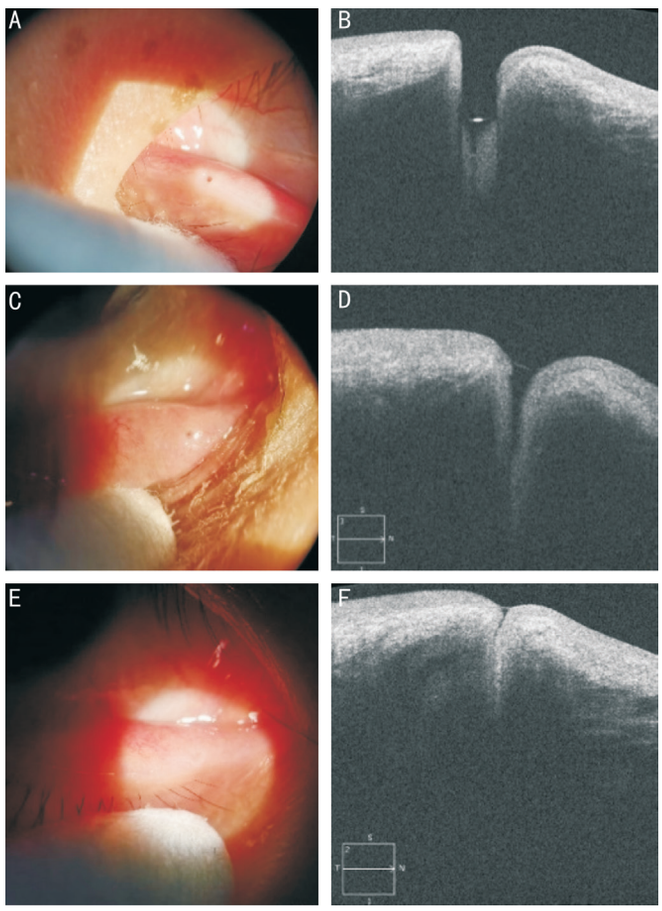

Figure 6 Primary punctum stenosis A: Slit lamp micrograph of a mild punctum stenosis; B: OCT imaging of a mild punctum stenosis; C: Slit lamp micrograph of a moderate narrow punctum; D: OCT imaging of a moderate punctum stenosis; E: Slit lamp micrograph of a severe punctum stenosis; F: OCT imaging of a severe punctum stenosis.

out developmental researches on OCT in the application of puncta imaging, such as measurement of relevant data (puncta diameter and depth), post-operative evaluation of puncta plasty. OCT imaging characteristics of tumors and systemic diseases mainly manifested in punctum[10-11]. Our team has completed the examination and measurement of normal Chinese adult puncta OCT[7], but so far there is few literature report on OCT imaging characteristics of puncta disease of Chinese patients.

The stenosis or atresia of lacrimal punctum will affect the drainage of tear and cause different degrees of epiphora symptoms. There are many factors that cause punctum changes, including infection, inflammation, systemic diseases, drug reactions, *etc*. It has been reported in the literature that OCT can assist in the assessment of puncta morphological abnormalities, such as puncta membrane obstruction, absence, tear, prolapse[12]. In this study, the patients with puncta membrane closure present different degrees of epiphora, and all of them are monocular, and the contralateral eyes are asymptomatic under the same conditions. There are also common clinical epiphora. OCT can observe that the

puncta membrane closure. They can be divided into complete membrane closure and incomplete membrane closure. Congenital lacrimal punctum absence should be considered whether it is combined with other lacrimal canaliculus structure absence. OCT of patients with lacrimal punctum absence in this study did not show canal structure, and it is suspected that there is corresponding lacrimal canaliculus absence at the same time. Retrograde exploration of incision of lacrimal sac during the operation found that lacrimal punctum absence and lacrimal canaliculus absence exist at the same time. Even if the chronic dacryocystitis patient does not provide the chief complaint of purulence, it can be seen that the purulent secretion overflows from the lacrimal punctum when pressing the lacrimal sac area or flushing the lacrimal passage. The chronic dacryocystitis patient in this study underwent punctum OCT imaging without flushing the lacrimal passage and other operations, and it can be seen that the purulent granule or deposits in the canal. During the observation process, it was found that the display effect of pus granule in OCT pseudo-color images was more obvious than that in gray-scale images. Therefore, pseudo-color imaging is recommended when observing the contents of punctum, including pus granule, tears, neoplasm, *etc*.

In this study, OCT imaging was performed on the punctum of patients with mild, moderate and severe primary punctum stenosis respectively. The results can clearly show that the punctum canal with mild stenosis is slightly narrower than that with normal punctum lumen, the punctum lumen with severe stenosis is obviously smaller like a slit, and the diameter of the punctum lumen with moderate stenosis is between mild and severe stenosis. OCT can clearly image different degrees and different forms of lacrimal punctum stenosis, further verify the visual observation results under slit lamp microscope, and also can display the stenosis degree inside the lacrimal punctum that cannot be checked by slit lamp microscope. Previous studies[3-6,13-15] have different results due to different examination methods and locations, while studies with similar examination methods and locations have similar results. The selection of this study is consistent with previous similar research methods, providing support and supplement for the future development of standardized examination methods for puncta OCT.

From previous reports, it can be seen that tumor or systemic disease involving lacrimal punctum can be the cause of the patient's first visit to the clinic, and it is also a hint of clinical diagnosis. For example, there are reports of IgG4-related diseases with inner canthus mass[16], conjunctival melanoma recurrence after excision with brown secretion overflowing from lacrimal punctum[17], bilateral dacryocyst squamous cell carcinoma with fleshy mass found at lacrimal punctum[18]. In 2018, Bothra *et al*[11] reported a case of upper eyelid cutin involving upper and lower lacrimal punctum. OCT showed that the lesion completely covered the lacrimal punctum and the lower proximal vertical lacrimal canaliculus lumen was not closed. Singh *et al*[10] used OCT to scan lacrimal canaliculus capsular expansion, which can clearly image the thickness and stratification of the capsule wall, the lacrimal punctum is not shown, because the expanded lacrimal canaliculus extrusion causes severe stenosis of the lacrimal punctum. Due to the large volume of the cyst and limited OCT penetration depth, the cyst and its relationship with surrounding structures cannot be completely displayed. Recently, some scholars reported that used OCT to examine congenital supernumerary lacrimal punctum, and the results showed two funnel shaped tissue gap corresponding cross-sectional image of supernumerary puncta[19]. It is also applied to analysis of cheese wiring after lacrimal passage intubation with tear function demonstrated that the integrity of the puncta and the canaliculus is important for lacrimal drainage[20]. In our study, 2 patients with dacryocyst tumor were collected. OCT showed that the tumor did not involve lacrimal punctum, the shape and size of lacrimal punctum were not significantly abnormal, and both patients had no lacrimation symptoms. In a case of lacrimal punctum tumor prolapse, the ruptured tumor was observed to be full of lacrimal punctum under slit lamp microscope. However, OCT showed that there was still a narrow but definite canal in the lacrimal punctum. The patient had mild lacrimation symptoms and underwent lower lacrimal canaliculus incision exploration plus tumor resection. During the operation, calculus was found in the lacrimal canaliculus, which was the same as the root of the tumor. Therefore, when other examination methods cannot clearly determine the situation of lacrimal punctum and the vertical part of lacrimal canaliculus, OCT scanning imaging examination can be considered to assist diagnosis and formulate treatment plan.

OCT is feasible for examination of lacrimal punctum lesions, and can be used as a good auxiliary method for clinical evaluation of lacrimal punctum. Analyzing the imaging characteristics of puncta lesions in OCT images can provide clinical diagnosis and treatment strategy formulation for puncta diseases. It should be pointed out that this study is only the preliminary application of OCT examination in the diagnosis of puncta diseases, and its sensitivity and standardization need to be further studied in a large sample.

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