·Clinical Research·

Diagnosis of lacrimal canalicular diseases using ultrasound biomicroscopy: a preliminary study

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Abstract

• **AIM: To evaluate the application of ultrasound biomicroscopy (UBM) in the examination of lacrimal canalicular diseases, and to investigate UBM image characteristics of lacrimal canaliculi in disease states.**

• **METHODS: Sixty cases (63 eyes, 69 canaliculi) of lacrimal canalicular diseases were enrolled that included 32 patients (32 eyes, 32 canaliculi) with chronic lacrimal canaliculitis, 18 patients (18 eyes, 18 canaliculi) with previous lacrimal canalicular laceration, 9 patients (12 eyes, 18 canaliculi) with congenital absence of lacrimal puncta and canaliculi, and 1 case (1 eye, 1 canaliculus) of canalicular mass. The patients were examined using UBM, and disease-specific features of the UBM images were noted.**

• **RESULTS: UBM imaging of lacrimal canaliculi in chronic canaliculitis patients showed obvious ectasia of the lacrimal canalicular lumen. Dot-like moderate echoic signals were detected on some ectatic lumina of the lacrimal canaliculus. Some lumen-like structures of the lower lacrimal canaliculus were observed in 2 (2 eyes, 2 canaliculi) of the 9 patients (12 eyes, 18 canaliculi) with congenital absence of the lacrimal canaliculus. Of the 18 patients (18 eyes, 18 canaliculi) with previous lacrimal canalicular laceration, the lacerated end on the nasal side of the lacrimal canaliculus was detected only in 14 patients (14 eyes, 14 canaliculi).**

• **CONCLUSION: UBM can be used to evaluate lacrimal canalicular diseases and can provide an imaging basis for the diagnosis of lacrimal canalicular diseases.**

• **KEYWORDS:** lacrimal canaliculus; ultrasound biomicroscopy; lacrimal canalicular calculus; previous canalicular laceration; congenital absence of canaliculus

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INTRODUCTION

The application of an imaging technique that can clearly display the structure of the lacrimal canaliculus would facilitate the diagnosis of lacrimal canalicular diseases. Considering the superficial position and elaborate structure of the lacrimal canaliculus, the frequently used imaging techniques, such as dacryocystography, B-scan ultrasound, computed tomography (CT), magnetic resonance imaging (MRI), and radioisotope scanning, for the examination of the lacrimal duct cannot clearly display the lacrimal canaliculus. Recent years, transcanalicular endoscopy has facilitated the examination of lacrimal canaliculi to detect lesion conditions, such as stenosis, stone, polyp, *etc* [1,2]. However, the technique cannot identify features such as a lacrimal canaliculus with congenital absence of the lacrimal puncta, an obstructed lacrimal canaliculus, as well as the relation of these features to their surrounding tissues. Ultrasound biomicroscopy (UBM) is a non-invasive technique in ophthalmology and has been widely applied in the evaluation of diseases of the anterior segment of the eye [3-7]. Due to its high resolution, UBM has a potential to be an ideal technique for the imaging examination of the lacrimal canaliculus. In recent years, UBM has been used in the examination of normal lacrimal canaliculus and in the detection of lacrimal canalicular diseases [8-13]; however, the sample sizes of these studies were small. In the present study, we examined 60 patients (63 eyes) with lacrimal canalicular disease and preliminarily examined the features of UBM images of several common types of lacrimal canalicular diseases, so as to provide an imaging basis for the diagnosis of lacrimal canalicular diseases.

SUBJECTS AND METHODS

Subjects A total 60 patients (63 eyes, 69 canaliculi) with lacrimal canalicular disease were enrolled in this study. Including 24 males (25 eyes, 28 canaliculi) and 36 females (38 eyes, 41 canaliculi), all of them were Chinese, aged between 18 and 82y, with a mean age of 41.5y. Of the total participants, 32 patients (32 eyes, 32 canaliculi) with chronic lacrimal canaliculitis, 18 patients (18 eyes, 18 canaliculi) with previous lacrimal canalicular laceration, 9 patients (12 eyes, 18 canaliculi) with congenital absence of lacrimal puncta and canaliculi, and 1 case (1 eye, 1 canaliculus) of canalicular mass. This study was conducted in accordance with the Declaration of Helsinki and was conducted with approval from the Ethics Committee of Armed Police General Hospital of China. Written informed consent was obtained from all participants. Subjects who met the

following criteria were excluded from the study: 1) subjects who had acute lacrimal canaliculitis or acute onset of chronic lacrimal canaliculitis; 2) subjects who had other type of acute and chronic inflammation of the eyes, such as hordeolum, keratitis, *etc*; 3) children; 4) subjects who had severe systemic disorders; and 5) subjects who were unwilling to participate in the study.

Methods The subjects were asked to lie in the supine position, and oxybuprocaine hydrochloride eye drops (4 g/L) were applied to the study eyes once every 5min. This was repeated three times to anesthetize the ocular surface. The subjects wore eyecups made by the modification of swimming goggles (Figure 1), which were filled with physiological saline injection [13,14]. To stretch the examined canaliculus, the study eyes were kept on the infratemporal region when examining the upper lacrimal canaliculus, and on the superotemporal region when examining the lower lacrimal canaliculus. The ultrasound detector of the SW-3200 full-scale UBM (Tianjin Suowei Electronic Technology Co., Ltd., Tianjin, China, the resolution is 40 μm, the frequency is 50 MHz) was placed on the eye region where the lacrimal canaliculus was located, indicatrix was kept vertical to the palpebral margin. The detector was first placed on a site about 5 mm lateral to the lacrimal punctum and then slowly shifted to the medial canthus. and the canalicular evaluation in both vertical and horizontal scanning. The characteristics of the UBM images of chronic lacrimal canaliculitis were observed and compared with the findings during surgery. The presence of the lacrimal canaliculus in the patients with congenital absence of lacrimal puncta was detected. Similarly, the presence of a lacerated end on the nasal side of the lacrimal canaliculus was also detected in patients with previous lacrimal canalicular laceration. All examinations were validated by surgery.

RESULTS

Chronic Lacrimal Canaliculitis Complicated by Lacrimal Canalicular Calculus Of the 32 patients (32 eyes, 32 canaliculi) with chronic lacrimal canaliculitis complicated by lacrimal canalicular calculus UBM examination revealed obvious ectasia of the lumen of the lacrimal canaliculus (Figure 2A) and remarkable symptoms of suppuration in 28 patients; a dot-like moderate echoic signal was found on the ectatic lumen of the lacrimal canaliculus (Figure 2B).

Congenital Absence of the Lacrimal Canaliculus Nine patients (12 eyes, 18 canaliculi) with congenital absence of lacrimal puncta and canaliculi manifested with tears in both eyes since childhood. Slit-lamp examination revealed absence of the upper and lower lacrimal puncta in both eyes in 3 patients (6 eyes, 12 canaliculi), revealed absence of the lower lacrimal puncta in one eye in 4 patients (4 eyes, 4 canaliculi), revealed absence of the upper lacrimal puncta in one eye in 2 patients (2 eyes, 2 canaliculi), and no trace of lacrimal punctum was detected. UBM examination showed

Figure 1 Modified swimming goggle serving as an eyecup.

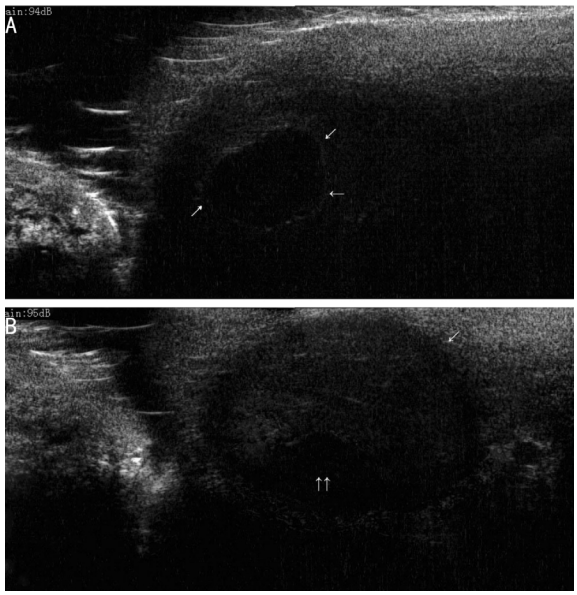

Figure 2 Characteristics of UBM images of chronic lacrimal canaliculitis A: The arrow shows ectasia of the lacrimal canaliculus; B: The arrow shows ectasia of the lacrimal canaliculus, and the double arrows show the dot-like, moderate echoic signals in the lumen of the lacrimal canaliculus.

no lacrimal canaliculus in 7 patients (10 eyes, 16 canaliculi) (Figure 3A), whereas lacrimal canalicular structure was observed at the proximal segment of the horizontal part of the lacrimal canaliculus in the other 2 patients (2 eyes, 2 canaliculi); however, the lumen of the lacrimal canaliculus was not distinct (Figure 3B), and the lumen-like structure was not detected at the distal segment of the horizontal and vertical part of the lacrimal canaliculus.

Lacrimal Canalicular Mass One case (1 eye, 1 canaliculus) with lacrimal canalicular mass had mucoid secretions in the left eye for a week. The case had undergone lacrimal duct intubation due to nasolacrimal duct obstruction of the left eye, and this onset of mucoid secretions of lacrimal canalicular mass occurred on 7d after extubation. The UBM examination revealed that the globoid mass (measuring about $0.99 \times 0.87 \times 0.68$-$mm^3$), with moderate echoic signal, even density, and broad basement, protruded from the lumen of the lacrimal canaliculus, and the bottom of the mass was connected with the wall of the lacrimal canaliculus (Figure 4). This mass removed *via* operation, and it's histopathology result was canalicular papilloma.

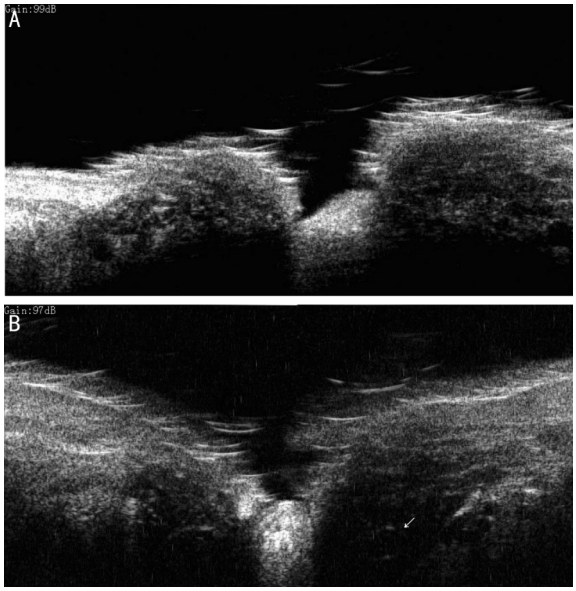

Figure 3 UBM images of the congenital absence of the lacrimal canaliculi A: Congenital absence of the lacrimal canaliculi. There was no lacrimal canaliculus-like structure observed in the region where the lacrimal canaliculus was located; B: Congenital partial absence of the lacrimal canaliculi. The arrow shows the lumen-like structure at the proximal segment of the lower lacrimal canaliculus. The lumen-like structure of the upper lacrimal canaliculus could not be distinctly observed.

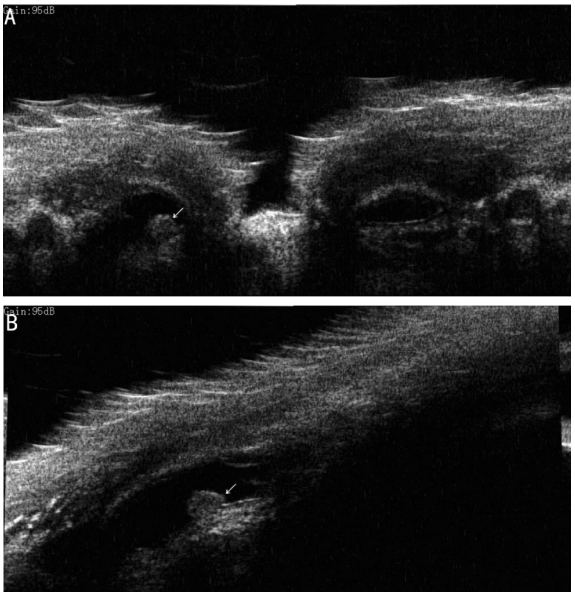

Figure 4 The arrows show UBM images of the lacrimal canalicular mass A: Cross-sectional view; B: Longitudinal-sectional view.

Previous Lacrimal Canalicular Laceration Of the 18 patients (18 eyes, 18 canaliculi) with previous lacrimal canalicular laceration, 14 patients (14 eyes, 14 canaliculi) had skin scarring approaching the temporal side of the horizontal part of the lacrimal canaliculus, without obvious medial canthal deformity. The lacerated end on the nasal side of the lacrimal canaliculus was successfully visualized in the UBM images, and it was generally positioned through measuring the vertical distances between the lacerated end and the skin surface, as well as the palpebral margin (Figure 5).

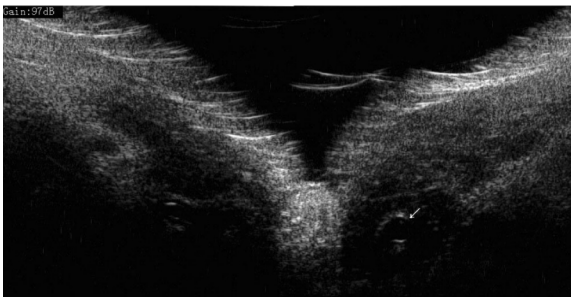

Figure 5 The arrow shows the lacerated end on the nasal side of the previous inferior lacerated canaliculus.

The other 4 patients (4 eyes, 4 canaliculi) had skin scarring approaching the nasal side of the horizontal part of the lacrimal canaliculus, with obvious medial canthal deformity. In these patients, UBM could not detect the lacerated end on the nasal side of the lacrimal canaliculus.

DISCUSSION

The normal lacrimal canaliculus is located 2-5 mm under the skin (superficially located near the punctum and deeply located near to the sac) with a diameter of 0.3-0.5 mm. As non-invasive technique in ophthalmology, UBM with the frequency of 50 MHz has a resolution of about 40 μm and a penetrability of about 4-5 mm. Due to its high resolution, UBM might become an ideal technique for the examination of the lacrimal canaliculus[13].

Chronic lacrimal canaliculitis is rarely detected in clinical practice and accounts for 2% of the lacrimal duct diseases[14]. In patients of chronic lacrimal canaliculitis, no abnormality or no mild redness and swelling on the skin was observed surrounding the lacrimal canaliculus, and pus was detected if the skin was pressed or a bean dreg-like substance was detected if the skin was squeezed. In spite of these distinct clinical characteristics of chronic lacrimal canaliculitis, misdiagnosis and missed diagnosis often occur [15-17]. Currently, the diagnosis of chronic lacrimal canaliculitis is mainly based on the clinical manifestations and the clinicians' experiences, which lack an objective basis. In the current study, 28 out of the 32 patients with chronic lacrimal canaliculitis displayed UBM features that were consistent with previous studies, and no dot-like moderate echoic signals were observed in the canalicular lumina of 4 patients[11]. One possibility for this finding is that various components of the yellow and white granular substances may have led to the formation of different features in UBM images. However, further studies are required to investigate the components of the yellow and white granular substances and the imaging characteristics of UBM.

Congenital absence of the lacrimal canaliculus, which is often complicated by the absence of lacrimal puncta, is a common congenital abnormality of the lacrimal drainage system. UBM examination was performed in 9 patients with congenital absence of the lacrimal canaliculus, and the examination results were compared with those of intraoperative observations. The results demonstrated the complete absence of the lacrimal canaliculus in 7 out of 9

patients with congenital absence of the lacrimal canaliculus; however the corresponding UBM examination did not detect the lumen-like structure. In addition, partial absence of the lacrimal canaliculus was observed in 2 patients. Currently, the diagnosis of congenital absence of the lacrimal canaliculus is made on the basis of the results derived from the exploration of probes, which are invasive and painful. Therefore, UBM examination provides an effective and non-invasive technique for the diagnosis of congenital absence of the lacrimal canaliculus.

In the current study, the features of the UBM images of lacrimal canalicular mass included a moderate echoic signal, an even density, and a broad basement, which are similar to the ultrasound characteristics of a polyp. In our study, the lacrimal canalicular mass was detected after lacrimal duct intubation. In addition to chronic inflammation, long-term mechanical stimulation of the silicone tube may be a major cause for the occurrence of the mass. Only one clinical case of a lacrimal canalicular papilloma, similar to the one detected in our study, has been reported [18]. The lacrimal canalicular papilloma detected in our study did not approximate the lacrimal punctum, leading to a difficulty in clinical observation. In addition, it was difficult for us to make a clinical diagnosis due to the atypical clinical symptoms and signs manifested by the subject. Nevertheless, our results suggest that UBM examination can serve as a guide for the diagnosis of lacrimal canalicular mass.

It is generally considered that a search for the lacerated end on the nasal side of the lacrimal canaliculus is the key for successful surgical repair of previous lacrimal canalicular laceration [19-21]. However, the formation of wound scar and lacrimal canalicular contracture make it challenging to search for the lacerated end on the nasal side of the previous lacerated lacrimal canaliculus. UBM examination in both vertical and horizontal scanning facilitates the search for the lacerated end on the nasal side of the lacrimal canaliculus and enables preliminary understanding of the condition prior to conducting surgery. In the present study, 18 patients showed previous lacrimal canalicular laceration, and UBM imaging did not detect the lacerated end on the nasal side of the lacrimal canaliculus in 4 patients. It is considered that the severe medial canthal deformity and the disordered structure in the region where the lacrimal canaliculus is located may affect the search for the lacerated end of the lacrimal canaliculus. Furthermore, the presence of a severely contractural lacrimal canaliculus below the medial canthal ligament and the limited penetrability of UBM may affect the visualization of the lacrimal canaliculus in UBM images.

In conclusion, UBM can be applied in the examination of lacrimal canalicular diseases, thus providing an imaging basis for the diagnosis of these disorders. The further studies are required to improve the current UBM apparatus and the accuracy and sensitivity of the UBM technique in the examination of lacrimal canalicular diseases in deep-layer tissues.

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