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CASE REPORT

Epithelial map-guided anterior stromal micropuncture for the treatment of recurrent corneal erosion syndrome

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Abstract
Purpose To introduce the use of corneal epithelial mapping by anterior segment optical coherence tomography (AS-OCT) as an ancillary testing for the identification of areas of loose epithelial adherence in recurrent corneal erosion syndrome (RCES), and the subsequent treatment of the latter with anterior stromal puncture (ASP).
Methods Five patients were presented with RCES following traumatic corneal abrasions. Following resolution of acute episodes, AS-OCT epithelial mapping was performed revealing in all patients an area of increased epithelial thickness (*hot spot*) corresponding to the site of loose attachment of the epithelium to the epithelial basement membrane. ASP to the area of epithelial thickening, as delineated by the epithelial map, was performed.
Results To date, none of the patients has shown any signs of disease recurrence over a period ranging from 6 to 20 months following the application of epithelial map-guided ASP.
Conclusions AS-OCT epithelial mapping can reveal the exact area of loose epithelial adherence in RCES. Hence, epithelial mapping can delineate the target area for treatment with ASP and may decrease the high failure rates of ASP.

Keywords Recurrent corneal erosion syndrome (RCES) · Corneal epithelial mapping · Anterior segment optical coherence tomography (AS-OCT) · Anterior stromal puncture (ASP)

Introduction

Recurrent corneal erosion syndrome (RCES) is characterized by the repeated detachment of basal cells of the corneal epithelium from the epithelial basement membrane. The condition may cause severe eye pain, photophobia, lacrimation, blepharospasm and blurring of vision due to corneal scarring. RCES is attributed, in almost half of the cases, to prior corneal abrasion [1]. Other etiologies of RCES include epithelial basement membrane corneal dystrophy, refractive surgery, herpetic ulcer, chemical burns, diabetes and dry eye syndrome [1–3].

Treatment modalities for RCES include conservative therapy (lubrication, hypertonic saline ointment, antibiotics, nonsteroidal anti-inflammatory drugs,

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autologous serum eye drops [4] and bandage soft contact lens), anterior stromal puncture (ASP), epithelial debridement/superficial keratectomy and phototherapeutic keratectomy (PTK).

In spite of being a simple and cost-effective procedure, ASP is not considered as the most favored method in clinical practice due to high rates of disease recurrence (17–24%) [1, 5]. High failure rates of ASP are commonly attributed to the inability to identify, and consequently treat successfully, the exact area of loose attachment of the basal epithelial layer to the basement membrane (BM).

In this report, we describe the application of ASP for post-traumatic RCES guided by epithelial mapping for the identification and subsequent treatment of the exact sites of loose epithelial adherence.

Materials and Methods

Case 1

A 30-year-old male sought medical consultation due to right eye discomfort, redness and lacrimation upon awakening. The patient described three similar episodes over the last 2 months that followed a fingernail-induced corneal abrasion. All episodes, including the initial trauma, were treated with intense lubrication and prophylactic instillation of antibiotic eye drops. The patient reported rapid alleviation of symptoms in all occasions within a few days following administration of the aforementioned regimen. Our patient's medical and ocular history was unremarkable; neither obvious systemic disease nor any previous ocular surgery was revealed.

The ophthalmic examination revealed uncorrected distance visual acuity (UDVA) 20/25 and 20/20 for the right and left eye, respectively. Slit-lamp biomicroscopy showed no pathological findings in the left eye, whereas in the right eye an epithelial defect was noticed in the inferior paracentral cornea. The defect that stained with fluorescein sized 4 mm in both horizontal and vertical diameter. Therefore, RCES of the right eye was diagnosed. A bandage contact lens (BCL) was applied; artificial tears and antibiotic drops (both conservative-free) were prescribed. Symptoms were ameliorated within 2 days. The BCL was removed 1 week since its application following epithelial healing.

Definitive treatment was required due to frequent disease recurrence and the debilitating nature of the symptoms. Corneal epithelial mapping by anterior segment optical coherence tomography (AS-OCT) using the comprehensive AngioVue system was performed. Significant epithelial thickness variation was observed along with an area of epithelial thickening in the inferonasal paracentral cornea (Fig. 1). Our assumption was that the area of "reactive" epithelial thickening (*hot spot*) corresponded to the site of the initial trauma and the area of hemidesmosomal breakdown and loose attachment of the basal epithelial layer to the BM. Therefore, we proceeded with anterior stromal puncture using a short 25 gauge-bent needle applied on the area of epithelial thickening as depicted on the epithelial map. The perforation depth was estimated at approximately 100 μm at the level of Bowman layer. Lubricating ointment at bedtime was administered postoperatively.

To date, 20 months post-ASP, no new episode of the disease has been reported while UDVA of the right eye is 20/20.

Case 2

A 36-year-old female was referred for evaluation of recurrent episodes of corneal abrasions in her right eye. The patient reported an initial shearing ocular injury from a tree branch along with 4 episodes of corneal epithelial defect over a 6-month period prior to her evaluation. The last episode was recorded a week prior to consultation.

The ophthalmic examination revealed uncorrected distance visual acuity 20/20 for both eyes. Slit-lamp biomicroscopy showed no pathological findings in the left eye, whereas in the right eye an area of loose epithelium in the inferior cornea was identified following application of gentle pressure with a surgical sponge.

Corneal epithelial mapping by anterior segment optical coherence tomography (AS-OCT) was performed revealing an area of epithelial thickening (*hot spot*) in the inferior paracentral cornea (Fig. 2). Similarly to the first case, we proceeded with anterior stromal puncture using a short 25 gauge-bent needle applied on the area of epithelial thickening. Bedtime lubrication was administered postoperatively.

No signs of disease recurrence have been observed 14 months following ASP.

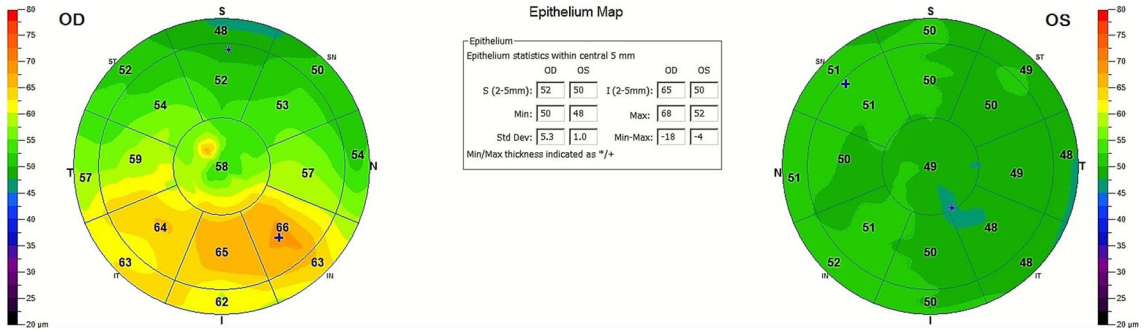

Fig. 1 Corneal epithelial mapping by anterior segment optical coherence tomography (AS-OCT). Epithelial thickening (*hot spot*) is observed in the inferonasal paracentral cornea of the right eye (map on the left)

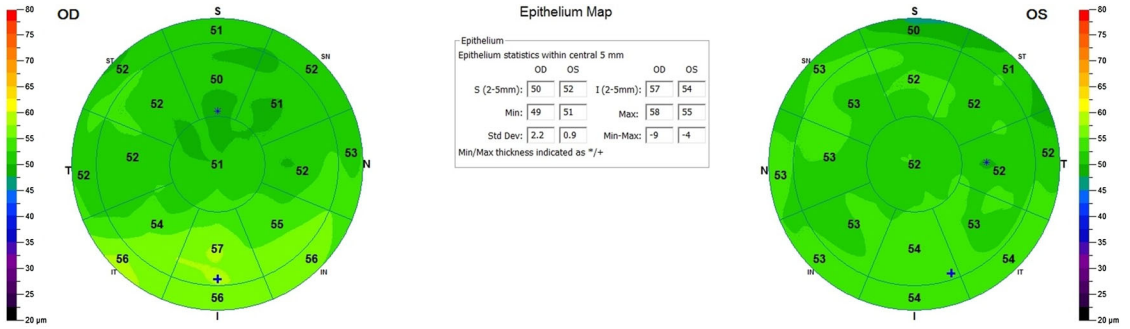

Fig. 2 Corneal epithelial mapping by anterior segment optical coherence tomography (AS-OCT). Epithelial thickening (*hot spot*) is observed in the inferior paracentral cornea of the right eye (map on the left)

Case 3

Our third patient, a 48-year-old female, reported almost ten episodes of corneal epithelial erosions in the right eye over the last 9 months. The initial trauma was a corneal laceration from the edge of a piece of paper (paper cut). Corrected distance visual acuity (CDVA) of the right eye was 20/20. The presence of thickened epithelium (*hot spot*) in the inferonasal paracentral cornea was depicted by AS-OCT corneal epithelium mapping (Fig. 3a) and epithelial map-guided ASP was applied. To date, 10 months post-ASP, no new episode has been recorded.

Case 4

A 31-year-old male has suffered from recurrent episodes of corneal epithelial defects in the left eye following an ocular trauma by fingernail 2 years ago. Patient reported frequent symptomatic episodes sometimes even on a weekly basis. Episodes were treated with the administration of intense lubrication and the occasional depending on the severity of the symptoms and the size of the defect application of bandage soft contact lens. No other treatment modality was used. Left eye CDVA was 20/20. AS-OCT corneal epithelial mapping revealed an area of epithelial thickening (*hot spot*) in the inferonasal paracentral and peripheral cornea (Fig. 3b). Epithelial map-guided ASP was performed. The patient remains episode-free 6 months following the application of ASP.

Case 5

Our last patient, a 47-year-old male, reported at the time of his evaluation an initial fingernail-induced corneal laceration in the left eye 10 months ago followed by monthly episodes of ocular pain and lacrimation. Episodes occurred at awakening and lasted for several hours while symptoms were ameliorated by the application of lubricating ointment. Left eye CDVA was 20/20. Corneal epithelial thickening in the central and inferotemporal paracentral cornea (*hot spot*) was depicted by AS-OCT epithelial

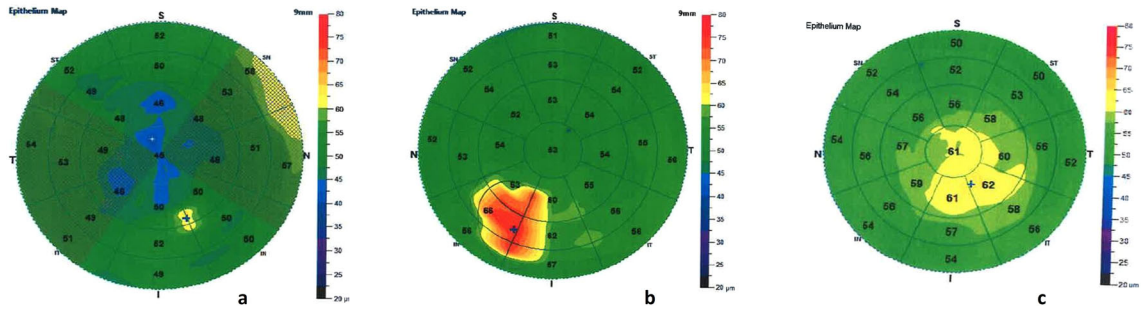

Fig. 3 Corneal epithelial mapping by anterior segment optical coherence tomography (AS-OCT), cases 3, 4 and 5. **a** Epithelial thickening (*hot spot*) in the inferonasal paracentral cornea, right eye. **b** Epithelial thickening (*hot spot*) in the inferonasal paracentral and peripheral cornea, left eye. **c** Epithelial thickening (*hot spot*) in the central and inferotemporal paracentral cornea, left eye

mapping (Fig. 3c). Micropunctures in the anterior stroma beneath the thickened epithelium were performed sparing the visual axis. No signs of disease recurrence have been observed 6 months following ASP.

Discussion

RCES can be a debilitating and even sight-threatening disease, thereby necessitating definitive treatment. In cases of post-traumatic RCES, epithelial mapping by AS-OCT can be a useful ancillary testing, assisting clinician's decision toward the optimal therapeutic intervention.

AS-OCT findings of corneas with RCES have been studied in the literature [6]. All patients suffering from acute RCES present anterior stromal hyper-reflectivity, epithelial edema and irregular breaks in the epithelium. AS-OCT findings of patients with chronic RCES include undetectable epithelial BM, intraepithelial BM, intraepithelial inclusions and anterior stromal hyper-reflectivity. On the other hand, epithelial mapping has been mainly studied in the literature as an early diagnostic tool for keratoconus (KC). Early keratoconic findings include a localized area of thinner epithelium over the cone surrounded by an annulus of thicker epithelium [7]. In addition, mean epithelial thickness is increased supranasally and reduced inferotemporally in keratoconic eyes (as opposed to normal eyes) [8].

ASP is a well-established treatment for RCES. Corneal needling induces localized subepithelial fibrosis and stimulates the production of extracellular matrix proteins that are important in the attachment of epithelial cells to the BM [3, 9]. However, ASP has fallen out of favor since the introduction of PTK in clinical practice, as it can cause scarring and subsequent visual disturbance. Furthermore, ASP has a high failure rate ranging from 17 to 24% [1, 5]—mainly due to the inability to identify and treat the exact areas of loose attachment of the basal epithelial layer to the basement membrane (BM).

We described five cases of post-traumatic RCES. In all cases, we performed epithelial mapping by AS-OCT. In the first case, epithelial mapping was performed following resolution of the acute episode revealing significant variance of the epithelial thickness along with an area of reactive epithelial thickening (*hot spot*) in the inferonasal paracentral cornea. Regarding cases 2 to 4, similar *hot spots* were depicted in the inferior paracentral, inferonasal paracentral and inferonasal paracentral–peripheral cornea, respectively. Case 5 presented an inferotemporal paracentral hot spot that extended to the central cornea (Table 1). In spite of PTK being acknowledged as the most effective treatment modality for RCES [10], our decision was in favor of ASP. According to our hypothesis, the eccentric *hot spot* that was depicted on epithelial maps correlated to the area of hemidesmosomal breakdown and loose epithelial adherence. The identification of the eccentric *hot spot* enabled us to perform epithelial map-guided ASP targeted to the exact area of loose epithelial attachment. The location of the *hot spot* beyond the visual axis in all but one of the cases lessened the risk of visual impairment from possible postoperative scarring. In case 5 where the hot spot extended to the central cornea, the application

Table 1 Clinical data of each case

Patient no.	Gender	Age	Eye	Initial trauma	*Hot spot*	No of recurrences	Duration of disease	Refraction	CDVA	Symptoms-free period post-ASP
1	Male	30	Right	Fingernail	Inferonasal paracentral	4	2 months	Emmetropia	20/25	20 months
2	Female	36	Right	Tree branch	Inferior paracentral	4	6 months	Emmetropia	20/20	14 months
3	Female	48	Right	Paper cut	Inferonasal paracentral	10	9 months	+ 1.25–2.25 × 160°	20/20	10 months
4	Male	31	Left	Fingernail	Inferonasal paracentral & peripheral	Once in a week	2 years	− 1.75–2.50 × 75°	20/20	6 months
5	Male	47	Left	Fingernail	Central & inferotemporal paracentral	Once in a month	10 months	− 8.50–2.00 × 165°	20/20	6 months

of micropunctures spared the visual axis. Adding to the above—in two of our cases—we decided in favor of ASP and against PTK, as laser treatment would induce a refractive error (commonly a hyperopic shift) [11, 12] to previously emmetropic patients. Furthermore, epithelial map-guided ASP constitutes a low-cost treatment modality for RCES compared to PTK. No signs of disease recurrence following treatment with epithelial map-guided ASP have been observed so far over a follow-up period of 6–20 months.

In conclusion, epithelial map-guided ASP may present a low cost-effective therapeutic modality for RCES as success rates can be augmented by the identification of the area of loose epithelial attachment as a *hot spot* depicted in AS-OCT epithelial mapping.

Compliance with ethical standards

Conflict of interest All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

Ethical approval All procedures performed in studies involving human participants were in accordance with the 1964 Helsinki Declaration and its later amendments.

Informed consent Informed consent was obtained from all individual participants included in the study.

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