• Clinical Research •

Evaluation of chronic ocular sequelae in patients with symblepharon caused by ocular burns

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Abstract

● **AIM:** To evaluate chronic ocular sequelae in patients with symblepharon caused by ocular burns and propose an objective grading system.

● **METHODS:** This was a retrospective, single-center clinical study. Patients with symblepharon caused by ocular burns at least six months later were assessed. Chronic ocular sequelae were classified into 3 categories (eyelid, conjunctiva, and cornea) and 9 chronic ocular sequelae [friction factors, exposure factors, conjunctival hyperemia, length of symblepharon, scope of adhesion, lacrimal area adhesion, loss of the palisades of Vogt (POV), corneal neovascularization, and corneal opacification]. Each ocular sequela was graded from 0 to 3, depending on the increasing severity. The 9 ocular sequelae were evaluated to obtain the total severity score for each eye. The total severity score was defined as Grade I (1-9), Grade II (10-18), and Grade III (19-27). Moreover, the correlation between the severity of chronic ocular sequelae and visual acuity, surgical strategy, and the prognosis was analyzed, respectively.

● **RESULTS:** Cases of 79 eyes with symblepharon caused by ocular burns were included in this study. Of these, 20 (25.32%) were defined as Grade I, 43 (54.43%) as Grade II, and 16 (20.25%) as Grade III. Eyes with a high total severity score had reduced visual acuity, required complicated surgery strategies, and poor prognosis (P<0.001). Multivariate regression analysis showed that the scope of adhesion, corneal opacification, and corneal neovascularization significantly affected visual acuity, surgical strategy, and prognosis (all P<0.001).

● **CONCLUSION:** The evaluation of chronic ocular sequelae enabled the development of an objective grading system for patients with symblepharon caused by ocular burns. This grading system can be applied to guide the treatment and predict the prognosis.

● **KEYWORDS:** chronic ocular sequelae; ocular burns; symblepharon; severity grading system

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INTRODUCTION

Symblepharon refers to any adhesion between the palpebral and bulbar conjunctiva resulting from ocular surface diseases, including autoimmune diseases such as Stevens-Johnson syndrome (SJS)[1-2], physical, thermal, or chemical trauma[3-4], and conjunctival surgery complications. Treatment of symblepharon caused by ocular burns (chemical burns and thermal burns) is rather challenging as it may be accompanied by tear film instability, tear reduction, and cicatricial entropion[5-6]. Hence, in the late stage of symblepharon after ocular burns, most eyes were in combination with chronic ocular surface sequelae, such as irregular corneal surface, inflammation, conjunctivalization, corneal vascularization, and poor epithelial integrity[7]. These ocular sequelae led to the dysfunction of the ocular surface, and each played a crucial role in affecting the treatment and prognosis of symblepharon. Taken together, symblepharon caused by ocular burns is accompanied by injury to the overall ocular surface, and the patients suffered a poor prognosis[8].

To date, the main therapy for treating symeblepharon is surgical treatment combined with the application of eye drops. Symblepharon lysis invariably creates a defect in the conjunctiva, which if left uncovered, might result in re-adhesion of the exposed surfaces[9]. To cover the palpebral or bulbar conjunctival defects, or both, conjunctival[6], amniotic membrane (AM)[10-11], oral mucosa[12-13], and nasal mucosa[14]

are alternative tissues for the development of various surgical procedures. Moreover, oral or nasal mucosa can be applied when the defect is sufficiently large or when palpebral conjunctiva is involved.

Chronic ocular sequelae in patients with symblepharon caused by ocular burns mainly include eyelid, conjunctival, and corneal sequelae. The treatment and prognosis in such cases lie on the severity of these ocular sequelae. In 2008, Kheirkhah *et al*[15] proposed a grading system for the severity of symblepharon. This system mainly considered the length and width of the symblepharon as well as the inflammation, which guided the selection of surgical strategy. However, the system put forward by Tseng *et al*[16] did not take other ocular surface manifestations, such as eyelid injury, into account. The previously reported success rates of symblepharon surgery were variable[16-18], which might be due to the lack of emphasis on the overall ocular surface manifestation. Therefore, it is necessary to propose an objective grading system of scoring the ocular sequelae for symblepharon caused by ocular burns which would assist in guiding treatment and predicting prognosis.

In this study, we retrospectively evaluated the chronic ocular sequelae of 79 patients (79 eyes) with symblepharon caused by ocular burns and proposed an objective grading system for severity that would have clinical implications. It would also provide a basis for the choice of treatment therapy and assessment of prognosis.

SUBJECTS AND METHODS

Ethical Approval This study was approved by the Institutional Review Board (IRB) of Shanghai Ninth People's Hospital Affiliated to the Shanghai Jiao Tong University School of Medicine.

Subjects A retrospective review was performed on the medical records of 79 patients (79 eyes) with symblepharon after ocular burns that had been operated on by one surgeon (Fu Y) at the Ophthalmology Department, from January 2013 through October 2017. Patients who underwent symblepharon surgeries were excluded from this study. The detailed medical history and ophthalmic photographic documentation of the included patients were collected and analyzed.

Classification and Grading of Chronic Ocular Sequelae Nine chronic ocular sequelae were vital for the evaluation of the ocular surface. Each ocular sequela was graded on a scale from 0 to 3, depending on the severity. The manifestations were classified broadly as eyelid sequelae, conjunctival sequelae, and corneal sequelae. Eyelid sequelae included friction factors such as entropion, trichiasis, and aberrant lashes, and exposure factors such as ectropion and palpebral margin defects as the evaluated components. The conjunctival sequelae consisted of the conjunctival hyperemia, length of symblepharon, scope of adhesion, and lacrimal area adhesion. Corneal sequelae involve loss of palisades of Vogt (POV), corneal neovascularization, and corneal opacification. The following classification and grading systems were applied to evaluate the severity of these nine manifestations.

Eyelid Sequelae

Friction factors Friction factors included entropion, trichiasis, and distichiasis. These were graded clinically from 0-3 as follows: 0: absence of friction; 1: the involved eyelid was less than one-third the length of both the upper and the lower eyelid; 2: the involved eyelid was one-third to two-thirds the length of both the upper and the lower eyelid; and 3: the involved eyelid was more than two-thirds the length of both the upper and the lower eyelid (Figure 1).

Exposure factors The exposure factors included ectropion and palpebral margin defects. These were graded clinically from 0 to 3 as follows: 0: absence of exposure; 1: the involved eyelid was less than one-third the length of both the upper and the lower eyelid; 2: the involved eyelid was one-third to two-third the length of both the upper and the lower eyelid; and 3: the involved eyelid was more than two-thirds the length of both the upper and the lower eyelid (Figure 1).

Conjunctival Sequelae

Conjunctival hyperemia Scoring of conjunctival hyperemia was based on the criteria proposed by Sotozono *et al*[19]. Conjunctival hyperemia was graded from 0 to 3 as follows: 0: absence of hyperemia; 1: mild hyperemia of conjunctival vessels; 2: diffuse hyperemia of conjunctival vessels; and 3: severe hyperemia of conjunctival vessels (Figure 2).

Length of the symblepharon The length of the symblepharon was defined as the shortest distance through the symblepharon from the lid margin to the limbus, as proposed by Kheirkhah *et al*[15]. It was graded clinically from 0 to 3 as follows: 0: it was greater than or equal to the normal length of the palpebral conjunctiva; 1: it was shorter than the normal length of the palpebral conjunctiva, but the length was equal to or greater than that of the normal tarsus; 2: it was shorter than the normal tarsus; and 3: it was close to zero because of ankyloblepharon (Figure 2).

Scope of adhesion The scope of adhesion was defined as the involved fornix area in reference to the length of both the upper and the lower fornix which was graded clinically from 0 to 3 as follows: 0: absence of adhesion; 1: the involved fornix area was less than one-quarter of the length of both the upper and lower fornix; 2: the involved fornix area was one-quarter to one-half the length of both the upper and the lower fornix; and 3: the involved fornix area was more than one-half the length of both the upper and the lower area (Figure 2).

Lacrimal zone adhesion The lacrimal zone was defined as the area where the lacrimal duct opened. The severity of

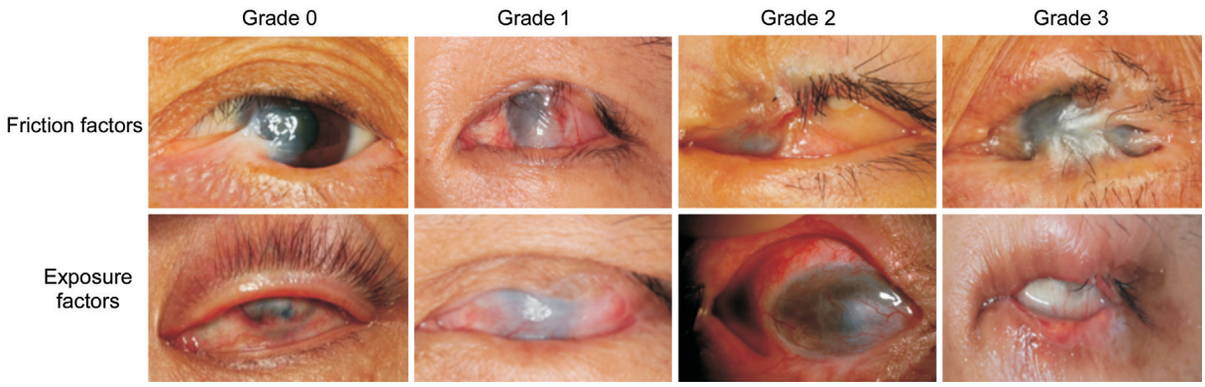

Figure 1 Grading of chronic eyelid sequelae.

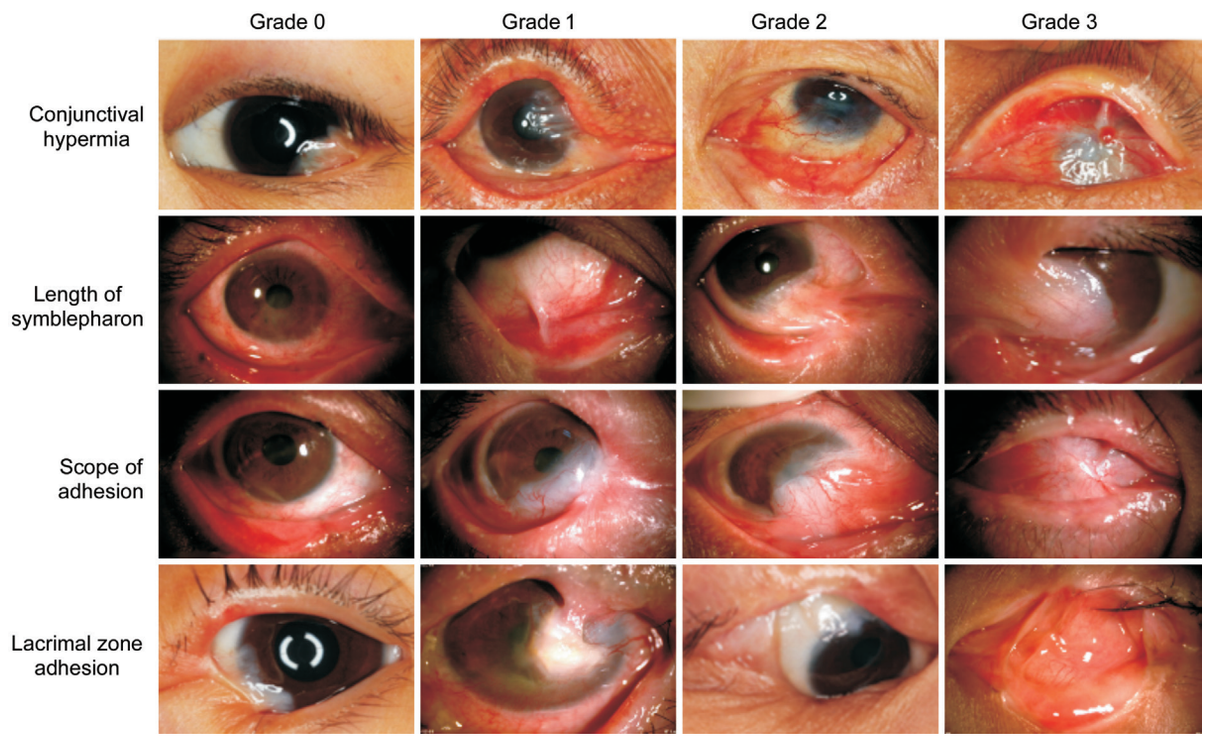

Figure 2 Grading of chronic conjunctival sequelae.

lacrimal zone adhesion was graded from 0 to 3 based on the following clinical features: 0: the absence of adhesion in the lacrimal zone; 1: less than one-third of the lacrimal zone had adhesions; 2: one-third to two-thirds of the lacrimal zone had adhesions; and 3: more than two-thirds of the lacrimal gland area showed adhesions (Figure 2).

Corneal Sequelae

Loss of the palisades of Vogt The extent of the loss of the POV was graded from 0 to 3, where 0 represents the presence of the entire circumference of POV, 1 denotes less than one-third of the entire circumference of the POV, 2 indicates one-third to two-thirds of the entire circumference of the POV, and 3 refers to more than two-thirds of the entire circumference of the POV (Figure 3).

Corneal neovascularization The severity of corneal neovascularization was defined from 0 to 3, where 0 denotes no neovascularization, 1 means neovascularization involving the corneal limbal, 2 represents neovascularization extending to the pupil margin, and 3 indicates neovascularization extending into the central cornea (Figure 3).

Corneal opacification The severity of corneal opacification was graded from 0 to 3, wherein 0 refers to no opacification, 1 represents partial obstruction of the iris details, 2 means only the pupil margin was visible, and 3 denotes complete obstruction of all details of the iris and pupil (Figure 3).

Grading system of the corneal sequelae was partially based on the grading system for the evaluation of chronic ocular manifestations in patients with SJS[19]. In eyes with severe symblepharon in which the cornea was involved, a score of 3 was assigned for corneal neovascularization and opacification.

Total Severity Score Each eye was evaluated and graded by three corneal specialists. When the scores differed between the specialists, the discrepancies were resolved after discussion and agreement. The scores were added together to obtain a

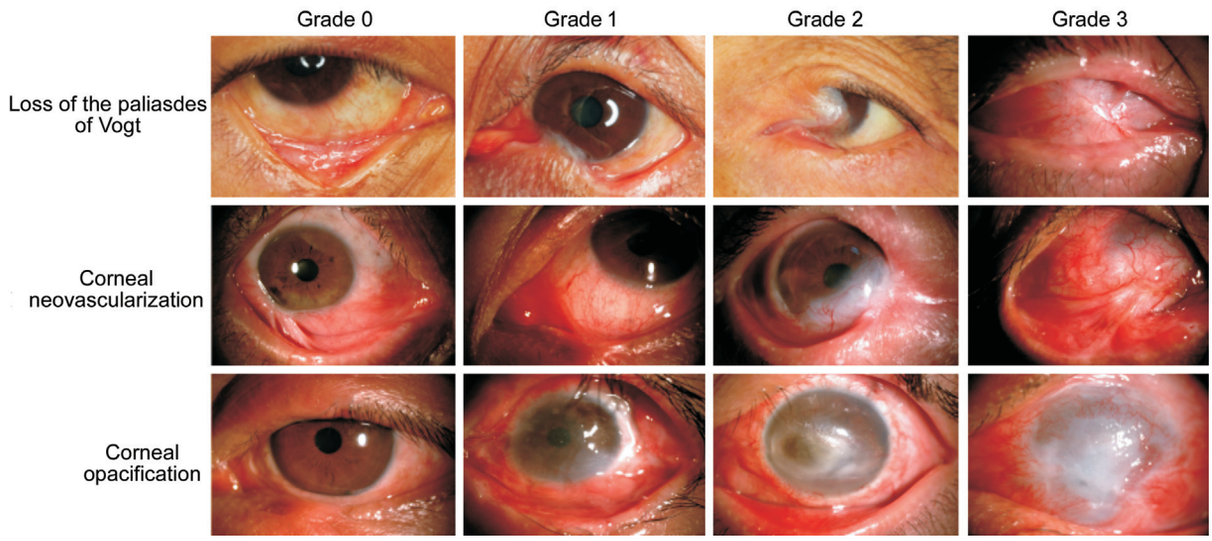

Figure 3 Grading of chronic corneal sequelae.

total score of 1-27, with 27 representing the most severely affected eyes. The 1-9 points were defined as Grade I, 10-18 as Grade II, and 19-27 as Grade III.

Visual Acuity The cases of 79 eyes were divided into two groups based on the visual acuity. In Group-α (*n*=48), visual acuity was worse than 20/200. In Group-β (*n*=31), visual acuity was ≥20/200 and up to 20/20.

Surgical Strategy This surgery strategy was based on a previously reported method. In the case of symblepharon eyes with severe eyelid complications such as lid margin deformity or trichiasis, eyelid reconstruction should be performed before or at the same time as the reconstruction of the ocular surface, such as free flap transplantation or pedicle flap transposition to cover the eyelid defect or incomplete closure. Also, marginal reconstruction should be conducted to improve the trichiasis eyelashes and eyelid margin defects. The adhesion of the conjunctiva needed to be removed, and the defect of the conjunctiva needed to be repaired after removal of the scar tissue. When the defect only affected the bulbar conjunctiva in a small range, the amniotic membrane or autologous conjunctival transplantation was used. When the defect involved the palpebral conjunctiva or the range was relatively large, the oral mucosa transplantation was applied to reconstruct the conjunctival sac.

For patients with severe corneal injury, some operations such as limbal stem cell transplantation and corneal transplantation could be used to further improve the visual acuity after the ocular surface became stable. The review of the patient's first ocular surface reconstruction strategy led to the division of the operations into three levels. The ocular surface reconstruction using amniotic membrane alone and/or autologous conjunctiva was defined as Surgery-A. When the oral mucosa was combined with the amniotic membrane transplantation (AMT) or autologous conjunctiva, Surgery-B was applied. The reconstruction of eyelid reconstruction before or at the same time as the ocular surface reconstruction was defined as Surgery-C.

Prognosis Prognosis was predicted by a corneal specialist at least three months after the first surgery. The restoration of an anatomically deep fornix without scarring or motility restriction was defined as no recurrence of adhesions. The focal recurrence of scar tissue was defined as partial recurrence of adhesions, whereas the return of symblepharon in the area of surgery denotes the recurrence of adhesions[15]. Herein, we defined the outcome with a specific score: 1 represents no recurrence of adhesions, 2 represents the partial recurrence of adhesions, and 3 represents the recurrence of adhesions.

Statistical Analysis Multivariate regression analysis was performed using SPSS software version 20 (SPSS Inc., Chicago, IL, USA) to determine whether the visual acuity, surgical strategy, and prognosis were correlated with the score of ocular sequelae. The Cochran-Armitage test and the Mann-Whitney *U* test were applied in this study. A *P*-value <0.05 was considered to be statistically significant.

RESULTS

This retrospective study included 79 eyes from 79 patients (68 males and 11 females), aged 37.9±16.4 (range 7-73)y. All patients visited our hospital at least six months after ocular burns. A total of 45 (57%) patients had undergone AM graft in early stage of ocular burns for corneal protection before they visited our center. The mean follow-up time was 34±18 (range 3-60)mo.

Correlation of Visual Acuity, Surgical Strategy, and Prognosis with Total Severity Score Total severity score showed a significant correlation with visual acuity, surgical strategy, and prognosis (*P*<0.001). Twenty eyes belonged to Grade I, of which, 18 (90.00%) eyes had visual acuity >20/200 (*P*<0.001), 15 (75.00%) suffered AMT and/or autologous

Table 1 Correlation of total severity score and visual acuity, surgical strategy as well as prognosis *n* (%)

Grade	Eye	Visual acuity			Surgical strategy			Prognosis			
		Group-α	Group-β	*P*	A	B	*P*	No recurrence	Partially recurrence	Recurrence	*P*
I (1-9)	20 (25.32)	2 (10.00)	18 (90.00)	<0.001	15 (75.00)	5 (25.00)	<0.001	19 (95.00)	1 (5.00)	0	<0.001
II (10-18)	43 (54.43)	30 (69.77)	13 (30.23)		5 (11.63)	38 (83.72)		18 (41.86)	23 (53.48)	2 (4.65)	
III (19-27)	16 (20.25)	16 (100.00)	0		0	16 (100.00)		3 (18.75)	10 (62.50)	3 (18.75)	

conjunctiva transplantation (P<0.001), and 19 (95.00%) have no recurrence of adhesion (P<0.001). Moreover, 43 eyes belonged to Grade II, of which, only 13 (30.23%) had visual acuity >20/200 (P<0.001), 38 (83.72%) underwent oral mucosal graft (OMG; P<0.001), and 25 (58.14%) had partial or complete recurrence of adhesions after surgery (P<0.001). Interestingly, all 16 eyes (100.00%) belonged to Grade III had visual acuity <20/200 and underwent OMG (P<0.001). Only 3 eyes (18.75%) did not show recurrence of adhesions post-surgery (P<0.001). In summary, with the elevated total severity score, the proportion of patients with visual acuity <20/200 increased (P<0.001). In addition, the proportion of OMG to reconstruct the ocular surface increased during surgery, and the probability of postoperative adhesion recurrence was high (P<0.001; Table 1).

Correlation of Nine Chronic Ocular Sequelae with Visual Acuity, Surgical Strategy, and Prognosis Eight chronic ocular sequelae except friction factors were statistically correlated with visual acuity, surgical strategy, and prognosis as showed by the Mann-Whitney U test (P<0.05). Among these, scope of adhesion, loss of the POV, corneal neovascularization, and corneal opacification had a statistically significant correlation with visual acuity, surgical strategy, and prognosis (P<0.001; Tables 2-4). Notably, differences were detected in the correlation between these nine chronic ocular sequelae and visual acuity, surgical strategy, as well as prognosis. In addition to the four ocular sequelae mentioned above, conjunctival hyperemia was also significantly related to visual acuity (P<0.001). Moreover, exposure factors, length of symblepharon, and lacrimal zone adhesion were significantly correlated to the surgical strategy (P<0.001). As for the prognosis, lacrimal zone adhesion was significantly related to it (P<0.001).

Table 2 Correlation between chronic ocular sequelae and visual acuity *n* (%)

Ocular sequelae	Score	Group-α (n=48)	Group-β (n=31)	*Z*	*P*
Friction factors	0	35 (72.9)	26 (83.9)	-1.224	0.221
	1	10 (20.8)	5 (16.1)		
	2	2 (4.2)	0		
	3	1 (2.1)	0		
Exposure factors	0	13 (27.1)	19 (61.3)	-2.727	0.006
	1	14 (29.2)	5 (16.1)		
	2	15 (31.2)	5 (16.1)		
	3	6 (12.5)	2 (6.5)		
Conjunctival hyperemia	0	3 (6.3)	7 (22.6)	-3.581	<0.001
	1	12 (25.0)	13 (41.9)		
	2	17 (35.4)	10 (32.3)		
	3	16 (33.3)	1 (3.2)		
Length of the symblepharon	0	1 (2.1)	3 (9.7)	-2.890	0.004
	1	7 (14.6)	7 (22.6)		
	2	11 (22.9)	13 (41.9)		
	3	29 (60.4)	8 (25.8)		
Scope of adhesion	1	17 (35.4)	23 (74.2)	-3.546	<0.001
	2	24 (50.0)	8 (25.8)		
	3	7 (14.6)	0		
Lacrimal zone adhesion	0	27 (56.3)	27 (87.1)	-2.947	0.003
	1	8 (16.7)	2 (6.5)		
	2	6 (12.5)	2 (6.5)		
	3	7 (14.6)	0		
Loss of the palisades of Vogt	0	1 (2.1)	7 (22.6)	-6.974	<0.001
	1	0	10 (32.3)		
	2	10 (20.8)	14 (45.2)		
	3	37 (77.1)	0		
Corneal neovascularization	0	3 (6.3)	17 (54.8)	-6.614	<0.001
	1	1 (2.1)	2 (6.5)		
	2	8 (16.7)	12 (6.5)		
	3	36 (75.0)	0		
Corneal opacification	0	1 (2.1)	9 (29.0)	-5.520	<0.001
	1	1 (2.1)	6 (19.4)		
	2	10 (20.8)	11 (35.5)		
	3	36 (75.0)	5 (16.1)		

DISCUSSION

The severity of chronic ocular sequelae in patients with symblepharon caused by ocular burns was investigated in this retrospective study. An objective grading system was proposed and all 79 patients were evaluated using this system. Eyes with a high total severity score exhibited poor visual acuity, requiring a complicated surgery strategy and exhibiting poor prognosis. In this study, we first emphasized the impact of the overall ocular sequelae on symblepharon caused by ocular burns and selected nine ocular surface manifestations as specific evaluation components. Moreover, the correlation of the nine ocular sequelae was different considering different observation indicators. For example, lacrimal zone adhesions had a significant correlation with prognosis (P<0.001). Therefore, these nine chronic ocular sequelae have been discussed further.

Table 3 Correlation between chronic ocular sequelae and surgical strategy *n* (%)

Ocular sequelae	Score	Surgery-A (*n*=20)	Surgery-B (*n*=59)	*Z*	*P*
Friction factors	0	17 (85.0)	44 (74.6)	-1.019	0.308
	1	3 (15.0)	12 (20.3)		
	2	0	2 (3.4)		
	3	0	1 (1.7)		
Exposure factors	0	16 (80.0)	16 (27.1)	-4.136	<0.001
	1	3 (15.0)	16 (27.1)		
	2	1 (5.0)	19 (32.2)		
	3	0	8 (13.6)		
Conjunctival hyperemia	0	4 (20.0)	6 (10.2)	-1.248	0.212
	1	6 (30.0)	19 (32.2)		
	2	8 (40.0)	19 (32.2)		
	3	2 (10.0)	15 (25.4)		
Length of the symblepharon	0	3 (15.0)	1 (1.7)	-3.828	<0.001
	1	7 (35.0)	7 (11.9)		
	2	7 (35.0)	17 (28.8)		
	3	3 (15.0)	34 (57.6)		
Scope of adhesion	1	19 (95.0)	21 (35.6)	-4.454	<0.001
	2	1 (5.0)	31 (52.5)		
	3	0	7 (11.9)		
Lacrimal zone adhesion	0	18 (90.0)	36 (61.0)	-2.549	<0.001
	1	2 (10.0)	8 (13.6)		
	2	0	8 (13.6)		
	3	0	7 (11.9)		
Loss of the palisades of Vogt	0	6 (30.0)	2 (3.4)	-4.688	<0.001
	1	6 (30.0)	4 (6.8)		
	2	6 (30.0)	18 (30.5)		
	3	2 (10.0)	35 (59.3)		
Corneal neovascularization	0	12 (60.0)	8 (54.8)	-4.700	<0.001
	1	1 (5.0)	2 (6.5)		
	2	6 (30.0)	14 (6.5)		
	3	1 (5.0)	35		
Corneal opacification	0	7 (35.0)	3 (5.1)	-4.056	<0.001
	1	4 (20.0)	3 (5.1)		
	2	5 (25.0)	16 (27.1)		
	3	4 (20.0)	37 (62.7)		

Table 4 Correlation between chronic ocular sequelae and prognosis

Ocular sequelae	Score	No recurrence of adhesions (*n*=40)	Recurrence of adhesions (*n*=39)	*Z*	*P*
Friction factors	0	33 (82.5)	28 (71.8)	-1.128	0.259
	1	6 (15.0)	9 (23.1)		
	2	0	2 (5.1)		
	3	1 (2.5)	0		
Exposure factors	0	21 (52.5)	11 (28.2)	-2.255	0.024
	1	9 (22.5)	10 (25.6)		
	2	7 (17.5)	13 (33.3)		
	3	3 (7.5)	5 (12.8)		
Conjunctival hyperemia	0	6 (15.0)	4 (10.3)	-2.120	0.034
	1	16 (40.0)	9 (23.1)		
	2	13 (32.5)	14 (35.9)		
	3	5 (12.5)	12 (30.8)		
Length of the symblepharon	0	4 (10.0)	0	-2.411	0.016
	1	7 (17.5)	7 (17.9)		
	2	16 (40.0)	8 (20.5)		
	3	13 (32.5)	24 (61.5)		
Scope of adhesion	1	29 (72.5)	11 (28.2)	-4.202	<0.001
	2	11 (27.5)	21 (53.8)		
	3	0	7 (17.9)		
Lacrimal zone adhesion	0	37 (92.5)	17 (43.6)	-4.511	<0.001
	1	1 (2.5)	9 (23.1)		
	2	1 (2.5)	7 (17.9)		
	3	1 (2.5)	6 (15.4)		
Loss of the palisades of Vogt	0	7 (17.5)	1 (2.6)	-4.820	<0.001
	1	10 (25.0)	0		
	2	14 (35.0)	10 (25.6)		
	3	9 (22.5)	28 (71.8)		
Corneal neovascularization	0	17 (42.5)	3 (7.7)	-4.256	<0.001
	1	3 (7.5)	0		
	2	10 (25.0)	10 (25.6)		
	3	10 (25.0)	26 (66.7)		
Corneal opacification	0	9 (22.5)	1 (2.6)	-5.037	<0.001
	1	7 (17.5)	0		
	2	14 (35.0)	7 (17.9)		
	3	10 (25.0)	31 (79.5)		

A high rate of eyelid sequelae was observed in patients with symblepharon caused by ocular burns. Friction or exposure factors were moderate or severe (score ≥2) in 39/79 eyes (49.37%) investigated. The scores of eyelid injury indicated the severity of eyelid conditions that could determine whether the eyelid involvements should be cured before the ocular surface reconstruction. As reported previously, the eyelid condition was a major factor for maintaining ocular surface stability and avoiding the involvement of factors such as infection and persistent epithelial defects[20]. Prabhasawat *et al*[21] also reported that severe corneal stromal abnormalities and severe eyelid deformity after cultivated limbal epithelial transplantation, complicated by postoperative epithelial defects and infection, resulted in treatment failures. Mild eyelid sequelae like mild lid margin deformities could be cured through cicatrix lysis. However, some patients with severe eyelid sequelae require eyelid reconstruction surgery, such as dermatoplasty. After the eyelid recovered to favorable status, the ocular surface could be reconstructed using keratoplasty in 3mo after the eyelid surgery. In the present study, patients (eyelid score ≥3) undergoing Surgery-C differed significantly from those with eyelid scores <3 (P<0.05; data not shown).

Conjunctival hyperemia could reflect the inflammatory status of the ocular surface, and the inflammatory reaction could lead to the deterioration of diseases. In addition, conjunctival injuries are always accompanied by the injury of goblet cells[22-23]. The production of mucin by these cells is vital for maintaining an adequate tear film that is essential for corneal clarity[19]. The deficiency of mucins produced by goblet cells can destabilize the tear film which potentially leads to final complications, such as long-term non-healing of the epithelium after surgery and re-adhesion of the conjunctiva.

The evaluation of the range of involved conjunctiva allowed to determine the surgery strategy. When the conjunctival sequelae were severe, oral or nasal mucosa might be needed to cover the palpebral or bulbar conjunctival defects. Patients with a score ≥4 (score of length of the symblepharon plus scope of adhesion) were significantly more likely to suffer OMG than those with a score <4 (P<0.05).

It is well-established that the lacrimal gland plays a crucial role in maintaining the health of the ocular surface due to secretion of proteins, electrolytes, and water[24]. The lacrimal gland fluid exits the gland onto the surface of the eye through the lacrimal gland excretory duct, which is the terminal portion of the duct system[25]. According to our clinical observation, a high proportion of patients with symblepharon caused by ocular burns suffered adhesions in the lacrimal gland area, which in turn, affects the function of the lacrimal gland, thereby affecting the stability of the tear film. Moreover, patients who suffered lacrimal zone adhesion also had a worse outcome than those without (P<0.001). In agreement with the previous report by Kheirkhah *et al*[9], patients with severe dry eye were excluded from this study. This might also explain the unsatisfactory prognosis of patients in the current study.

Ocular burns can lead to limbal stem cell deficiency (LSCD) which finally results in neovascularization and conjunctivalization of the cornea. As a result, the patient felt discomfort (burning, pain, and photophobia) and eventually suffered vision loss[26]. Thus, we evaluated the severity of corneal complications. The findings indicated that different surgery strategies should be chosen based on the differential severity of corneal complications. For example, mild to moderate limbal stem cell deficiency could be resolved by conjunctival limbal autograft accompanied by keratoplasty. In addition, severe limbal stem cell loss might require invasive surgeries, such as Boston artificial keratoplasty. These surgeries should be completed within 6mo after ocular surface reconstruction with sufficient consideration of the surgery risk.

In conclusion, in this study, we evaluated the chronic ocular sequelae of patients with symeblepharon after ocular burns and proposed an objective grading system. This is the first study that included nine ocular sequelae in the grading system while evaluating the severity of symblepharon after ocular burns. The current approach could not only provide appropriate guidance on the treatment but also predict the prognosis. Each patient should be evaluated preoperatively such that the treatment of symblepharon can be standardized.

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