CLINICAL AND EXPERIMENTAL
OPTOMETRY

RESEARCH PAPER

Punctal function in lacrimal drainage: the 'pipette sign' and functional ectropion

Clin Exp Optom 2015; 98: 366–369 DOI:10.1111/cxo.12279

Bijan Beigi* MD FRCS FRCOphth
Deepak Gupta* MRCOphth
Yvonne H-L Luo* MA (Cantab) MRCOphth
Manuel Saldana* FRCOphth
Ilias Georgalas† MD PhD
George Kalantzis† MD PhD
Nabil El-Hindy* FRCOphth
*Norfolk and Norwich University Hospital, United Kingdom
†University Ophthalmology Department, Athens, Greece
E-mail: igeorgalas@yahoo.com

Submitted: 15 June 2014
Revised: 16 December 2014
Accepted for publication: 21 December 2014

Background: The aim was to assess the movements of the inferior punctum during blinking and discuss pertinent clinical applications.
Methods: This is a prospective, non-comparative observational case-series examining the function of inferior punctum during blinking using video recordings of the blinking action at the slitlamp with slow-motion analysis and comparison.
Results: In all 56 eyes of 28 patents, supero-medial movement of the lower punctum toward the medial canthus, together with a medially directed protrusion of the inferior punctum was noted. It was also noted that the punctum blanched during this projectile movement compared to the rest of the lid margin.
Simultaneous posterior rotation of the punctum was also observed in 48 eyes (85.7 per cent; 23 right eyes and 25 left eyes), resulting in apposition of the punctum to the lacus lacrimalis. In eight eyes (14.3 per cent; five right eyes and three left) from six patients, co-existence of medial punctal ectropion led to failure of internal rotation of the punctum during blinking, even though punctal 'pipette formation' was preserved. These six patients all suffered from epiphora in the affected eyes. The presence of 'pipette' formation was calculated to have a sensitivity of 80 per cent and specificity of 100 per cent for punctal ectropion in our series. A two-tailed Fisher exact test showed that based on our 56 eyes, these results were statistically significant ($p < 0.0001$).
Conclusions: The inferior punctum plays an active and important role in the drainage of tears by the mechanism of supero-medial movement and medially directed protrusion ('pipetting action'), failure of which contributes to epiphora. This is a highly specific sign and should be sought in the evaluation of epiphora, even in the absence of frank ectropion. In punctual stenosis where location of the punctal orifice is proving difficult, inducing the pipette sign will help in its identification.

Key words: ectropion, epiphora, lacrimation, punctum

Epiphora is one of the more common ophthalmic symptoms and specifically describes persistent welling of tears in the eye, occurring when these spill over. It is caused by overproduction of tears or by inadequate or blocked drainage. Drainage of tears that are not lost to evaporation or absorbed by the lacrimal system, takes place by the inferior and superior canaliculi into the lacrimal drainage system.[1,2] Tears can also be lost to lid margin overflow as in epiphora or lacrimation. Drainage involves a number of mechanisms.[3] Capillary attraction plays a significant role.[4,5] This is aided by contraction, in a superior direction, of the lacrimal part of the orbicularis muscle (Horner's muscle) with blinking with completion of lid closure compressing both canaliculi and the lacrimal sac, forcing the tears through the drainage system.[6–8] Expansion of the lacrimal sac during the opening phase of blink causes suction and after opening of the eyelids, the punctal, canalicular and lacrimal sac vacuum breaks to reload with tear fluid.[5,8] There is also thought to be a passive wringing out of the sac because of its medial attachment and helically arranged fibrillar structures.[3]

In the above processes, the puncta are usually thought of as only minute orifices through which tears gain entry into the canalicular system. As described below, movements of the inferior punctum during blinking suggest that the punctum plays a significant role in tear drainage. This paper assesses these movements and we suggest that clinical assessment of this movement should form part of any baseline evaluation of epiphora. Clinical applications are discussed.

METHODS

This is a prospective, non-comparative observational case-series study of the function of the inferior punctum during blinking. The study was performed according the tenets of the Declaration of Helsinki. Careful slitlamp observation of the movement of the inferior punctum during blinking was carried out on 56 eyes of 28 consecutive patients, who attended the eye clinic in a two-month period. With slitlamp microscopy, during blinking, we looked for medial movement and protrusion of the inferior punctum forming a finger-like projection akin to a 'pipette tip' and posterior rotation and apposition of the

'pipette tip' to the lacus lacrimalis. Video recordings of the blinking action in a patient with a normal lacrimal drainage system and a patient with punctal ectropion suffering from epiphora were performed to allow slow-motion analysis and comparison. During filming, the upper eyelid of the subject was held up manually to allow a clearer view of the motion of the inferior punctum during blinking. A drop of two per cent fluorescein was then instilled into the eye to allow better visualisation of the marginal tear strip.

Symptoms of epiphora (defined as excess tearing from one or both eyes) as well as the punctum size of each patient was recorded and graded according to the system proposed by Kashkouli, Beigi and Astbury.[9] Patients with pipette formation with posterior rotation of the pipette into the lacus lacrimalis with no resultant epiphora were deemed 'normal'. By contrast, patients with pipette formation with anterior rotation of the pipette away from the lacus lacrimalis with resultant epiphora were deemed 'abnormal'. In this way, 'normal' patients are those with no symptoms of epiphora and no eyelid malposition. Patients with previous eyelid or lacrimal surgery, lump overlying or involving the punctum and /or other parts of the lacrimal drainage system and known nasolacrimal system obstructions were excluded from the study.

RESULTS

Patients were aged between 34 and 86 years. In all 56 eyes of 28 patents, detailed slitlamp observation revealed that during blinking, contractions of Horner's muscle bring about a supero-medial movement of the lower punctum, from its resting position adjacent to the globe toward the medial canthus, together with a medially directed protrusion of the inferior punctum, forming a finger-like projection akin to a 'pipette tip', in a fashion similar to pouting of the lips with contraction of the orbicularis oris (Figure 1).[10] It was also noted that a small ring surrounding the punctum (peri-punctal area) blanched during this projectile movement, compared to the rest of the lid margin (Figure 2).

Simultaneous posterior rotation of the punctum was observed in 48 eyes (85.7 per cent; 23 right and 25 left eyes), resulting in apposition of the punctum to the lacus lacrimalis. Combination of 'pipette formation' and apposition of the pipette tip to the lacus lacrimalis allowed total submergence of the punctum in the pool of tears accumulated at the lacus lacrimalis, thereby facilitating siphoning of tears from the lacrimal lake (during the opening phase of the blink). Slow-motion analysis of the video clips confirmed this role of the punctum in tear drainage during blinking.

In eight eyes (14.3 per cent; five right and three left eyes) of six patients, a failure of posterior rotation of the punctum during blinking was noted, even though punctal 'pipette formation' was preserved (Figure 3, Table 1). As a result, the protruded punctal pipette tip was left pointing into free air (Figure 4), when suction force from the lacrimal sac resulted in sucking in only air from the atmosphere rather than tears from the lacrimal lake. These six patients all suffered from epiphora in the affected eyes (Table 2). The presence of 'pipette' formation and apposition to the lacus lacrimalis was calculated to have a sensitivity of 80 per cent and specificity of 100 per cent for punctal ectropion, in our series. A two-tailed Fisher exact test showed that based on our 56 eyes, these results were statistically significant ($p < 0.0001$).

It is worth noting that patient number 22 also suffered from lacrimation despite having an intact punctal pipetting function and drainage system. This can be attributed to his condition of bilateral acne rosacea blepharitis, giving rise to overflow epiphora rather than inadequacy of tear drainage.

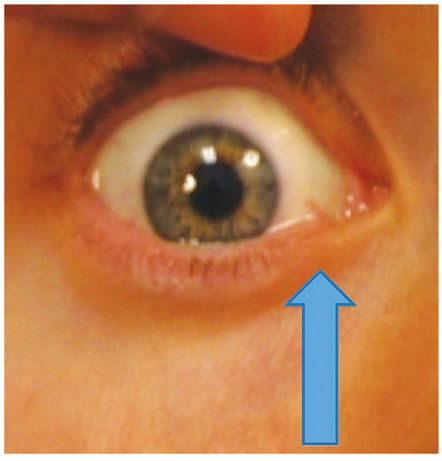

Figure 1. The inferior punctum is shown to move supero-medially into the lacus lacrimalis during blinking. Medial lid margin and punctum remain in apposition to the globe under normal circumstances (blue arrow).

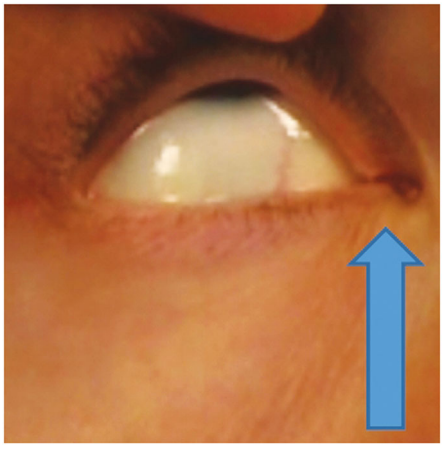

Figure 2. Blanching of peri-punctal area. Sign induced by holding lower lid in everted position asking patient to blink (blue arrow).

DISCUSSION

The lacrimal canaliculus consists of vertical and horizontal portions and the common canaliculus.[11] The vertical, initial part of the canaliculus comprises the punctum (puncta

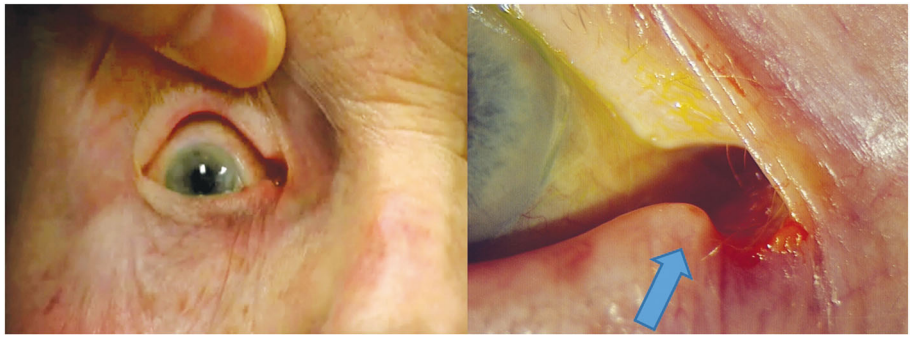

Figure 3. Primary position of the inferior punctum in a right eye with punctal ectropion before blinking (blue arrow).

Patient number	Age (years)	Pipette formation	
		Right eye	Left eye
1	34	Yes	Yes
2	73	Yes	Yes
3	82	Yes	Yes
4	82	Yes	Yes
5	72	Yes	Yes
6	82	Yes	Yes
7	75	Yes	Yes
8	75	Yes	Yes
9	83	Yes	Yes
10	45	Yes	Yes
11	76	Yes	Yes
12	73	Yes	Yes
13	66	Yes	Yes
14	46	Yes	Yes
15	38	Yes	Yes
16	49	Yes	Yes
17	58	Yes	Yes
18	47	Yes	Yes
19	80	Yes	Yes
20	34	Yes	Yes
21	61	Yes	Yes
22	64	Yes	Yes
23	43	Yes	Yes
24	72	Yes	Yes
25	78	Yes	Yes
26	35	Yes	Yes
27	43	Yes	Yes
28	86	Yes	Yes
Total		28	28

Table 1. Clinical data of patients observed for punctal pipette formation during blinking

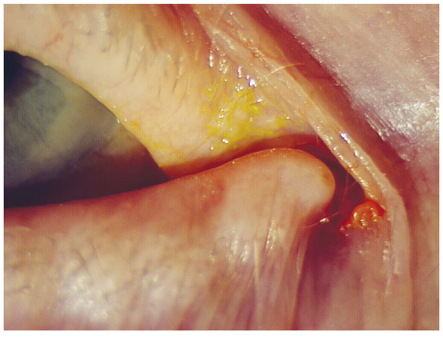

Figure 4. Protrusion of the punctal pipette away from the lacus lacrimalis, into the medial canthal region, during blinking in punctal ectropion.

	Pipette tip to lacus lacrimalis		Epiphora		Punctal size		Additional comments	
Patient number	Right eye	Left eye	Right eye	Left eye	Right eye	Left eye	Right eye	Left eye
1	Yes	Yes	No	No	3	3		
2	**No**	**No**	**Yes**	**Yes**	**2**	**2**	**Lower lid ectropion**	**Lower lid ectropion**
3	**No**	**No**	**Yes**	**Yes**	**1**	**1**	**Lower lid ectropion; canalicular narrowing**	**Lower lid ectropion; canalicular narrowing**
4	*No*	*Yes*	*Yes*	*No*	*1*	*1*	*punctal phimosis*	*punctal phimosis*
5	Yes	Yes	No	No	3	3		
6	Yes	Yes	No	No	3	3		
7	Yes	Yes	No	No	3	3		
8	Yes	Yes	No	No	3	3		
9	Yes	Yes	No	No	3	3		
10	Yes	Yes	No	No	3	3		
11	Yes	Yes	No	No	3	3		
12	*No*	*Yes*	*Yes*	*No*	*3*	*3*	*Lower lid punctal ectropion*	
13	*Yes*	*No*	*No*	*Yes*	*3*	*2*		*Lower lid punctal ectropion*
14	Yes	Yes	No	No	2	3		
15	Yes	Yes	No	No	3	3		
16	Yes	Yes	No	No	2	3		
17	Yes	Yes	No	No	2	2		
18	Yes	Yes	No	No	3	3		
19	Yes	Yes	No	No	2	2		
20	Yes	Yes	No	No	3	3		
21	Yes	Yes	No	No	3	4		
22	Yes	Yes	Yes	Yes	3	3	Acne rosacea blepharitis	Acne rosacea blepharitis
23	Yes	Yes	No	No	3	3		
24	Yes	Yes	No	No	3	3		
25	*No*	*Yes*	*Yes*	*No*	*3*	*3*		
26	Yes	Yes	No	No	3	3		
27	Yes	Yes	No	No	3	3		
28	Yes	Yes	No	No	3	3		
Total	0	0	0	0				

Patients 2 and 3 (in bold) are abnormal bilateral cases
Patients 4, 12, 13 and 25 (in italics) are abnormal unilateral cases

Table 2. Clinical data of patients observed for punctal tip apposition to the lacus lacrimalis during blinking, together with symptoms of epiphora and punctal size

lacrimalia) that lies on the summit of a papilla (papillae lacrimales), situated on the posterior eyelid margin.[5,12] The vertical portion is generally two millimetres long, inclined laterally by five degrees and dilates at its base to form a receptacle for tear collection, called the 'ampulla'.[11,13] The vertical portion is surrounded by the muscle of Riolan or Horner's muscle.[14] The canaliculus then turns horizontally in a medial direction parallel to the eyelid margin.[11]

The puncta come into full contact after one-third to one-half of the full downward excursion of the upper lid.[5] The five degrees

lateral inclination augments the medially directed punctal projection during eyelid closure, while the vertical portion changes its direction medially because of the inward eyelid movement caused by the contraction of Horner's muscle.[10,13,14] The negative pressure (vacuum effect) resulting from the subsequent expansion of the lacrimal sac is transmitted to the tear menisci via the elastic expansion of the canaliculi during the interblink interval. With ensuing relaxation of the orbicularis oculi muscle, the punctal areas separate and the vacuum is broken during the eyelid opening phase resulting in drainage of tear fluid from the marginal tear strip and lacus lacrimalis.

Our observation has certain clinical implications. In a patient with epiphora, in the absence of frank medial ectropion, the pipette sign should be sought as part of an assessment of lid position. A minimal amount of ectropion may cause epiphora.[15] It was absent in all patients but six eyes of eight patients showed punctal ectropion. If there is early/sub-clinical ectropion, it will be revealed by the punctum moving anteriorly, away from the lacus lacrimalis. We refer to this as 'functional punctal ectropion' in our lacrimal clinic. Typically, management of functional ectropion will involve procedures to restore the posterior rotation movement of the punctal tip. The Fox diamond tarsoconjunctival excision combined with inverting sutures is one possible solution.

Acquired external punctal stenosis / phimosis is a common cause of epiphora and in descending order of frequency, has been attributed to chronic blepharitis, idiopathic phenomenon, ectropion and drug side-effects.[16] Clinicians may experience difficulty identifying the site of a blocked punctum. The blanching induced when the pipette sign is invoked, in the manner described above, will facilitate identification of its location.

In conclusion, the inferior punctum plays an active and important role in the drainage of tears by its pipetting action, failure of which contributes to epiphora. Tears drawn into the upper canalicular system via the superior punctal route alone may not be sufficient to facilitate complete tear drainage. This is a highly specific sign and should be sought in the evaluation of epiphora and differential diagnosis of excess lacrimation, especially in the absence of frank ectropion. In punctal stenosis/blockage, where location of the punctal orifice is proving difficult, inducing the pipette sign will help in its identification.

REFERENCES

1. Mustarde JC. *Repair and Reconstruction in the Orbital Region*, 3rd ed. New York: Churchill Livingstone, 1993. pp 299–302.
2. Paulsen F. Anatomy and physiology of efferent tear ducts. *Ophthalmologe* 2008; 105: 339–345.
3. Paulsen F, Thale A, Hallmann U, Schaudig U, Tillmann BN. The cavernous body of the human efferent tear ducts: function in tear outflow mechanism. *Invest Ophthalmol Vis Sci* 2000; 5: 965–970.
4. Hill JC, Bethell W, Smirmaul HJ. Lacrimal drainage: a dynamic evaluation. *Can J Ophthalmol* 1974; 9: 411–416.
5. Doane MG. Blinking and the mechanics of the lacrimal drainage system. *Ophthalmology* 1981; 88: 844–851.
6. Thale A, Paulsen F, Rochels R, Tillmann B. Functional anatomy of the human efferent tear ducts: a new theory of tear outflow mechanism. *Graefes Arch Clin Exp Ophthalmol* 1998; 236: 674–678.
7. Becker BB. Tricompartment model of the lacrimal pump mechanism. *Ophthalmology* 1992; 99: 1139–1145.
8. Pavlidis M, Stupp T, Grenzebach U, Busse H, Thanos S. Ultrasonic visualization of the effect of blinking on the lacrimal pump mechanism. *Graefes Arch Clin Exp Ophthalmol* 2005; 243: 228–234.
9. Kashkouli MB, Beigi B, Astbury N. Acquired external punctal stenosis: surgical management and long-term follow-up. *Orbit* 2005; 24: 73–78.
10. Shinohara H, Kominami R, Yasutaka S, Taniguchi Y. The anatomy of the lacrimal portion of the orbicularis oculi muscle (tensor tarsi or Horner's muscle). *Okajimas Folia Anat Jpn* 2001; 77: 225–232.
11. Doxanas MT, Anderson RL. *Clinical Orbital Anatomy*. Baltimore: Williams and Wilkins, 1984. pp 99–100.
12. Hwang K, Kim DJ, Hwang SH. Anatomy of lower lacrimal canaliculus relative to epicanthoplasty. *J Craniofac Surg* 2005; 16: 949–952.
13. Kakizaki H, Takahashi Y, Nakano T, Asamoto K, Kinoshita S, Iwaki M. Course of the vertical portion of the lower lacrimal canaliculus. *Clin Ophthalmol* 2008; 2: 753–756.
14. Kakizaki H, Zako M, Miyaishi O, Nakano T, Asamoto K, Iwaki M. The lacrimal canaliculus and sac bordered by the Horner's muscle form the functional lacrimal drainage system. *Ophthalmology* 2005; 112: 710–716.
15. Kakizaki H. Medial canthal anatomy and the lacrimal drainage system. *Nihon Ganka Gakkai Zasshi* 2007; 111: 857–863.
16. Mustarde JC. *Repair and Reconstruction in the Orbital Region*, 3rd ed. New York: Churchill Livingstone, 1993. p 405.