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Measuring the lacunar sulci as a new indicator of shrinkage of the ocular surface

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PURPOSE. *To present a new indicator that measures the sulci of the lacrimal lake of the eye according to the degrees of ocular abduction at which they vanish. This new approach will help determine the severity and progression of mucosal retraction in ocular surface diseases.*
METHODS. *A total of 181 eyes of 94 healthy persons, 130 eyes of 65 patients with Sjögren's syndrome, and 30 eyes of 15 patients with ocular pemphigoid were examined using the slit lamp. We recorded the vanishing point of the three main lacunar sulci (plico-bulbar, plico-caruncular and dermo-caruncular) while abducting.*
RESULTS. *In healthy persons, the average vanishing points for the first and second lacunar sulci were respectively, 53.2° ± 12.3 and 54.5° ± 9.8. In patients with Sjögren's syndrome, 49.53° ± 10.81 and 53.17° ± 7.28 and in patients with incipient ocular cicatricial pemphigoid, 42.69° ± 14.33 and 44.46° ± 16.85. Statistical significance was $p < 0.005$.*
CONCLUSIONS. *The lacunar sulci are shallower and vanish sooner in ocular cicatricial pemphigoid and Sjögren syndrome than in normals. Investigating the vanishing point of the lacunar sulci while abducting is useful for grading the shrinkage of the conjunctiva, caruncle and medial canthus. (Eur J Ophthalmol 2001; 11: 227-32)*

KEY WORDS. *Lacunar sulci, Dry eye, Keratoconjunctivitis sicca, Sjögren's syndrome, Ocular pemphigoid, Pterygium*

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INTRODUCTION

Many diseases cause mucosal shrinkage. The most common in ophthalmology are ocular cicatricial pemphigoid and erythema multiforme (Stevens-Johnson syndrome). However, many other affections can produce conjunctival shrinkage, such as microbial infections (adenovirus 8 and 19, diphtheria, β-hemolytic streptococcus), atopic keratoconjunctivitis, sarcoidosis, scleroderma (progressive systemic sclerosis), topical eyedrops (practolol, epinephrine, echotiophate iodide, iodo-desoxyuridine, pilocarpine, timolol, dipivalyl epinephrine) (1-12), and sometimes Sjögren syndrome, epidermolysis bullosa, dermatitis herpetiformis, bullous pemphigoid, pemphigus vulgaris, and linear IgA diseases (13). Certain conditions such as bullous pemphigoid and pemphigus, are not usually believed to cause conjunctival scarring (14, 15).

Right now there is no sound indicator to measure the small retractions of the ocular surface caused by these ocular or systemic conditions, which means that the initial stages of retraction are often overlooked.

The most common method of measuring shrinkage of the conjunctiva is to quantify the deletion of the lower fornix folds and the strings of symblepharon of the inferior fornix (16-19). To do this, the lower eyelid is pulled downwards while the patient looks up. The problem with this method is that it is imprecise

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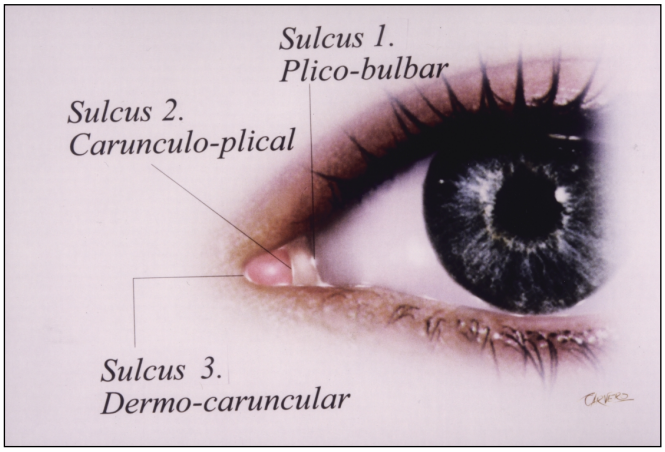

Fig. 1 - *Lacunar sulci. Sulcus 1, between the plica semilunaris and bulbar conjunctiva. Sulcus 2, between the plica semilunaris and caruncula lacrimalis. Sulcus 3, between the caruncula lacrimalis and lid skin.*

and only allows belated measurements.

While seeking a more accurate approach, we have developed a new method to measure and grade the shrinkage of the lacunar sulci in its early stages (20-22). In the medial canthus of the interpalpebral fissure there are several folds and sulci, three of which are very conspicuous and permanent in the primary position of the gaze (Fig. 1). From the lateral to medial side these sulci are: 1) plico-bulbar, 2) plico-caruncular, and 3) dermo-caruncular. Since they are found in the lacrimal lake, we have called them lacunar sulci.

The first lacunar sulcus, the plico-bulbar sulcus, is located between the plica semilunaris and the bulbar conjunctiva of the medial exposed trigonus, its upper half in front of the tendineous portion of the medial rectus, it runs downwards and slightly laterally until it ends behind the lower lid near the lower cul-de-sac. The second lacunar sulcus, the plico-caruncular, runs between the plica semilunaris and the caruncula lacrimalis. Being Y-shaped, there is an area between its upper branches that belongs to the caruncle and not to the plica, so this sulcus actually follows the lateral branch. The third lacunar sulcus – dermo-caruncular – runs between the caruncle and the margin skin of both medial canthus lids. It is V-shaped (>shaped in the right eye, and <shaped in the left eye).

When the eyeball is abducted, the sulci of the lacrimal lake in the interpalpebral fissure become more and more superficial until they eventually disappear. The degrees of abduction at which the sulci vanish could be a useful indicator for grading their amplitude, and for following the progression of ocular surface retraction in mucoso-cutaneous or lacrimal diseases.

MATERIALS AND METHODS

At the Ophthalmology Department at the Hospital Ramón y Cajal, Madrid, 341 eyes of 174 consecutive patients were included in this study which took place between March 1997 and March 2000. The subjects were classified in three groups: normals, Sjögren syndrome, and ocular cicatricial pemphigoid.

The inclusion criterion for controls was attendance at the Opthalmology Unit for ametropias. Exclusion criteria were any ocular surface diseases, dermatological diseases, immune diseases or dry eye. This group comprised 181 eyes of 94 patients, 80 males and 101 females. Their ages ranged between 20 and 73 years.

The inclusion criteria for the Sjögren's syndrome group were mild or medium dry eye with some other exocrinopathia sicca (eyes, mouth, nose, vagina, etc) and lymphoid infiltration from the labial salivary gland. Exclusion criteria were any other cicatrizing disease of the ocular surface (trachoma, caustication) or severe Sjögren syndrome with permanent signs such as corneal haze, scarring or neovascularization. This group comprised 130 eyes of 65 patients, 16 males and 49 females. Their ages ranged between 23 and 68 years.

The inclusion criteria for ocular cicatricial pemphigoid were an initial stage of the disease with a positive indirect or direct immunofluorescence test. This group included 15 patients, 8 male and 7 female. Ages ranged between 23 and 52 years.

All patients underwent a general ophthalmological examination, specifically including examination of their lower conjunctival fornicial folds and the lacunar sulci. The conjunctival folds were studied at the slit lamp, with the patient's head in the right position (Fig. 2a). The first step was to evert the lower lid, obliging the subject to look up and noting whether the lower fornicial folds seemed normal or dubious (0), had any appreciable retraction (+), were absent or almost absent (++), or if there were any antero-posterior tractional folds (+++).

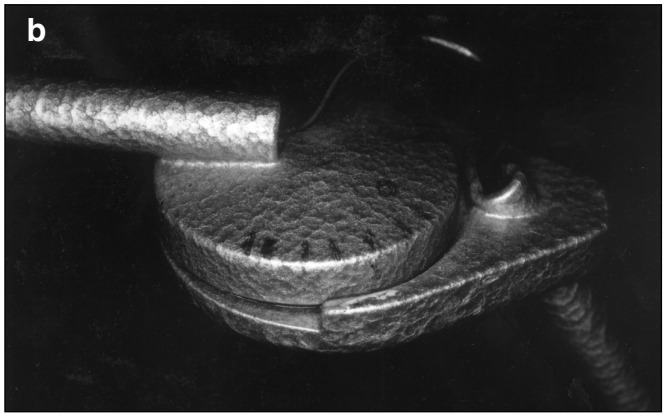

Fig. 2 - ***a)*** *The patient sits at the slit lamp and the fixation light is placed right in front of the eye.* ***b)*** *The anterior part of the rotation disc of the fixation lamp is marked in sexagesimal degrees.*

The next step was to dye the lacrimal sea with fluorescein by introducing a strip soaked with colorant under the lower lid or by instilling a fluorescein drop. Any mucus threads on the lacunar folds were removed, and excessive tear was absorbed with a surgical sponge or gauze. The ultraviolet filter of the slit lamp was then inserted in the light beam. The lacrimal lake and its three main sulci were examined, with the patient gazing in the primary position. Once the excess of fluorescein was removed, we could observe three fine fluorescent lines instead of the lacunar sulci.

Next, the specialist asked the patient to fix the gaze on a light placed in front of the eye being examined. The subject was then asked to follow the light which was displaced laterally around the patient's head in the horizontal plane of the eyes. At one point in the

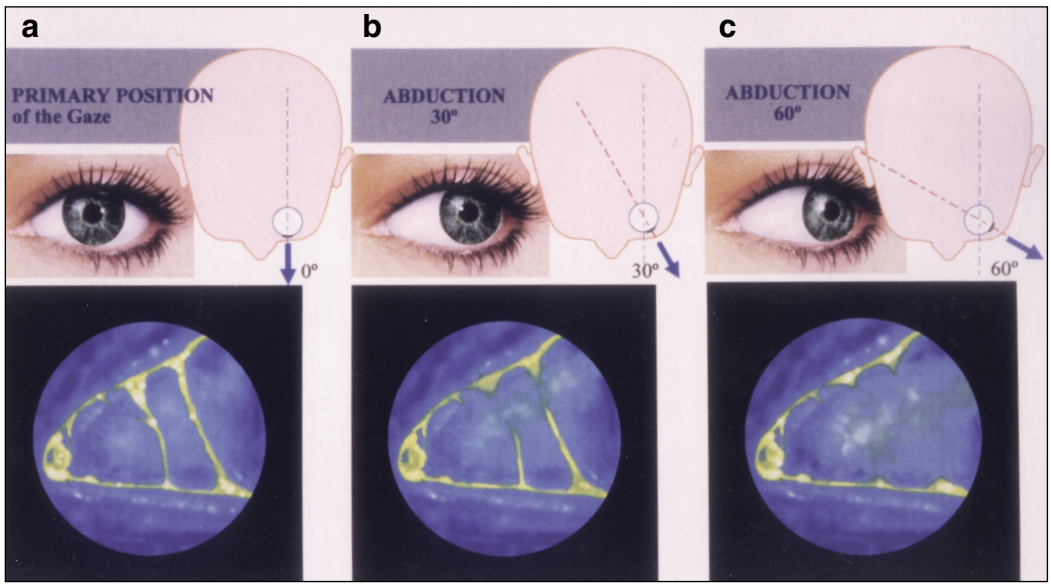

Fig. 3 - *Fluorescein is dropped into the eye, and the lacunar sulci are observed under UV illumination.* ***a)*** *In primary position of the gaze the three lacunar sulci (plico-bulbar, plico-caruncular and dermo-caruncular) are present in normal eyes.* ***b)*** *When abducting moderately (in this case 30°), the three sulci persist in normal cases, but can vanish in ocular surface retraction cases.* ***c)*** *At maximum abduction (55-60°), sulci 1 and 2 are near their vanishing point in normal eyes, but have vanished in cases of ocular surface retraction.*

ocular abduction the yellow/fluorescent lines break up due to the stretching, becoming many tiny fluorescent points or almost invisible horizontal lines. Minuscle horizontal folds replace the previous vertical sulcus (Fig. 3). The sexagesimal degree of abduction at which this occurred in a sulcus was recorded as the vanishing point for this particular lacunar sulcus.

The patient was then asked to return the gaze to the primary position so we could note when the yellow line of the sulcus reappeared. Then the abduction was slowly repeated in order to verify the degree of vanishing. The degree of abduction at which the fluorescein strips of the three lacunar sulci broke up was recorded for each of the three lacunar sulci. If on reaching the maximum abduction point (usually 55-60°) a sulcus still mantained its continuity, the figure was entered followed by an *n*, to indicate that it had *n*ot broken up.

Sometimes in pathological cases, and despite evident shrinkage of the ocular mucosas, the yellow strip of the plico-bulbar sulcus does not disappear because there is prominent hypertrophic tissue, inflammation or a cicatrice causing a protrusion or a vertical string of the plica semilunaris. When this was the case, we added an *h* or *h*? after the notation *n*, depending on whether the hypertrophy was certain (*h*) or dubious (*h*?).

Usually, the upper part of the fluorescein line vanished first, and if the difference between top and botton was more then 5°, this sulcus was entered not as a single figure but as a fraction, the numerator expressing the breaking point in the top half, and the denominator the breaking point for the lower half.

In healthy eyes and in the majority of ocular surface diseases the third sulcus (dermo-caruncular) never vanished. Consequently, we only recorded cases where the sulcus disappeared, not when it was normal. For instance, *OD 30/60n, 25* means that in the right eye, the upper part of the first sulcus vanished partly or completely at 30°, and that the lower half maintained the fluorescein strip until it reached the maximum abduction rate of 60°. The second sulcus vanished at 25°. The third sulcus kept the top 60° abduction point (Fig. 3).

To establish the exact position of the fixation point and the degree of abduction at which the sulci vanished we marked the rotation disc of the fixation lamp in sexagesimal degrees (Fig. 2), or painted two 90° arches of circumference on the slit lamp table, one at each side of the patient: 0° in front of the patient's eyes and 90° at each side of it.

The sulci marked with "*h*" (tissue hypertrophy, inflammation or scar retraction) were eliminated from the analysis, and results were processed for statistical analysis of average and standard deviation (SD).

RESULTS

Normal subjects. In these 181 eyes of 94 persons without ocular surface diseases and with normal lower cul-de-sac folds, while the gaze was in the primary position, the three lacunar sulci were always present, either in their whole length or in part. When ab-

TABLE I - SEXAGESIMAL DEGREES OF ABDUCTION AT WHICH THE FIRST (PLICO-BULBAR), SECOND (PLICO-CARUNCULAR) AND THIRD (DERMO-CARUNCULAR) LACUNAR SULCI VANISHED IN 341 EYES OF 174 CONTROLS (CS) WITHOUT OCULAR SURFACE DISEASE, WITH SJÖGREN SYNDROME (SS) OR WITH OCULAR CICATRICIAL PEMPHIGOID (OCP), 60n MEANS THAT THE SULCUS DID NOT VANISH AT THE MAXIMUM ABDUCTION OF 60°

Condition	No. Eyes/ patients	Sex M/F	Smoothing of the lacunar sulci when abducting ($\bar{X}$ ± SD, in sexagesimal degrees)				
			1st sulcus		2nd sulcus		3rd sulcus
			Upper part	Lower part	Upper part	Lower part	
CS	181/94	80/101	47.20° ± 13.70	59.10° ± 7.01	50.80° ± 11.30	58.20° ± 6.61	60n
SS	130/65	16/49	45.16° ± 13.14	53.98° ± 10.24	49.02° ± 10.24	57.50° ± 5.90	60n
OCP	30/15	8/7	36.92° ± 17.05	48.46° ± 13.07	39.29° ± 18.41	49.29° ± 15.57	60n

ducting, the first sulcus disappeared at an average (± SD) of 53.2° ± 12.3 faster in the upper part than in the lower one, at 50.9° ± 13.0 in people under 40 years old and 54.8° ± 11.4 in those over 40. The second sulcus disappeared at an average of 54.5° ± 9.8, faster in the upper part than in the lower one, and in people under 40 years old (52.6° ± 9.9) than over 40 (53.1° ± 11.5). The third lacunar sulcus never disappeared (Tab. I).

Sjögren's syndrome. In the 130 eyes of 65 patients with mild or medium Sjögren's syndrome there was no evidence of lower cul-de-sac retraction, though it may sometimes be so insignificant that it might be overlooked by this method. The three lacunar sulci were present at the primary position of the gaze, except in one case which lacked the first sulcus, and another which lacked the second.

While abducting, the 1st sulcus vanished at an average and standard deviation of 49.53° ± 10.81, faster in the upper part than in the lower one (Tab. I). The second sulcus vanished at an average of 53.17° ± 7.28, first in the upper part then in the lower one. The third sulcus never disappeared.

Ocular cicatricial pemphigoid. In the 30 eyes of 15 patients with mild ocular cicatricial pemphigoid in which retraction of the lower fornix was dubious or very mild, one lacunar sulcus was missing in the primary position of the gaze in two eyes, though the sulci reappeared during adduction. While abducting, the sulci disappeared in most cases. The first sulcus vanished at an average of 42.69° ± 14.33, first in the upper part and then in the lower one (Tab. I). The second lacunar sulcus vanished at 44.46° ± 16.85, first in the upper part. Then in the lower one. The third lacunar sulcus never disappeared.

DISCUSSION

The first examination sign of conjunctival shrinkage in clinical practice is shrinkage of the lower cul-de-sac. However, in its early stages lower cul-de-sac shrinkage is impossible to evaluate so its quantification as a percentage (16, 17) is imprecise. Other indirect signs of initial ocular surface shrinkage may be instability of the tear film and the loss of goblet cells, proved by impression cytology, but these are not very specific tests.

Lacunar sulci are easy to examine, and can easily be measured and graded. Therefore, studying the lacunar sulci may be the first and easiest test when we suspect ocular surface shrinkage. Although some publications (16, 17) have argued that fibrosis of the bulbar and lid conjunctiva involves the inferior fornix first, this has never been proved. We do not know whether shrinkage of the ocular surface occurs first in the cul-de-sac or in the lacrimal lake, or simultaneously, but our test does show that it can be measured first in the lacrimal lake and only afterwards in the lower cul-de-sac.

Normal lacunar sulci vary from person to person and tend to be asymmetrical. They increase with age, especially in the upper part which becomes more persistent with age (22). In patients with Sjögren's syndrome the lacunar sulci are shallower than in normal subjects, and vanish first while abducting, the difference being significant ($p < 0.005$). In patients with ocular cicatricial pemphigoid, shrinkage of the ocular surface can first be seen in the lacunar sulci and subsequently in the inferior fornix, and the increasing retraction, which is difficult to determine in the lower fornix, can be easily checked in the lacunar sulci.

The third sulcus never disappeared, not even in ocular pemphigoid cases, because we selected patients in the initial stages of the disease, where conjunctival retraction could not be detected. In cases where a part or the whole lacunar sulcus was absent in the primary position of the gaze, we can make the patient adduct the eyeball to establish the degrees at which it reappears.

In a current parallel study on the relations between the lacunar sulci and other ocular surface diseases, including Sjögren's syndrome, ocular cicatricial pemphigoid, erythema multiforme, pterygium, trachoma and episcleritis, we have found significant differences between the various diseases, maybe because the three lacunar sulci are histologically very different. The first is a conjunctival sulcus; the second is limited medially by caruncular tissue with goblet cells, lipid glands and hair; and the third sulcus has dermal tissue on the medial side. Therefore, shrinkage of the various lacunar sulci possibly depends on the etiopathogenesis and histopathogenesis of the specific ocular surface diseases. Further studies are being carried out to clarify this point. We can advance some observations from this ongoing study: in nine cases of pterygium with less than 2 mm of corneal invasion, the first lacunar sulcus vanished at 17.2° ± 13.5 / 32° ± 27.3,

the second at 25.62° ± 15.1 / 44.3° ± 21.08, and the third at 60n. In 11 cases of immune episcleritis with no apparent ocular surface symptoms the first lacunar sulci vanished at 48.4° ± 16.2 / 58° ± 11.50, the second at 30.3° ± 10.6 / 51° ± 11.27 and the third at 60n. In this study we found a positive correlation between the point where the lacunar sulci vanish and a reduced goblet cell count in the plica semilunaris and the medial trigonal conjunctiva.

CONCLUSIONS

The lacunar sulci disappeared sooner in patients with ocular cicatricial pemphigoid and Sjögren's syndrome than in normals. The differences were significant, especially in the upper stretch of the first lacunar sulcus. The most important conclusion is that the vanishing point of the lacunar sulci at a given degree of abduction is a valuable, quick, and easy test for routine office examination. It is also a much more precise sign of retraction of the conjunctiva than the smoothing of the lower cul-de-sac folds.

Further linear studies are needed in patients with different dry eye, ocular surface and mucoso-cutaneous conditions, in order to see how the lacunar sulci decrease as these diseases progress.

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