

# Corneal topography and Schirmer testing in eyes with the Hudson–Stahli line

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## Abstract

**Purpose** To evaluate corneal topographic features and tear secretion in eyes with the Hudson–Stahli line.

**Methods** Keratometry, computerized videokeratography and Schirmer testing were performed in 50 cases with bilateral Hudson–Stahli line, and 55 controls without the Hudson–Stahli line. Similar tests were performed in 21 subjects with unilateral Hudson–Stahli line.

**Results** Corneal topographic features and keratometry in the horizontal meridian were similar in cases and controls, and in fellow eyes of subjects with unilateral Hudson–Stahli line. Keratometry in the vertical meridian in cases ( $43.01 \pm 2.01$ ) was significantly lesser than in controls ( $43.94 \pm 1.77$ ) ( $P = 0.01$ ). This value was not different in fellow eyes of patients with unilateral Hudson–Stahli line. Schirmer testing revealed significantly greater tear secretion in cases ( $16.72 \pm 4.99$  mm) compared to controls ( $12.57 \pm 3.62$  mm) ( $P < 0.01$ ). In subjects with unilateral Hudson–Stahli line, mean Schirmer values in the eye with the line ( $17.52 \pm 6.86$  mm) were significantly greater than in eyes without ( $13.67 \pm 4.64$  mm) ( $P = 0.04$ ).

**Conclusion** Formation of the Hudson–Stahli line may be dependent on the presence of normal tear secretion in the eye.

*Eye* (2002) 16, 267–270. DOI: 10.1038/sj/eye/6700028

**Keywords:** corneal topography; Hudson–Stahli line; tear secretion

The Hudson–Stahli line, described independently by Hudson and Stahli, is a fine, horizontal, brown line in the corneal epithelium along the line of lid closure.<sup>1</sup> It is

formed by the deposition of iron in the epithelium of an otherwise normal cornea and is considered a physiological change, seen more frequently with increasing age.<sup>2</sup> The source of iron and etiopathogenesis of the Hudson–Stahli line remain controversial, although tear film pooling is thought to be important.<sup>3</sup> Recent studies have reported the formation of corneal pigment lines after corneal refractive surgery, suggesting that alterations in corneal surface contour may play an important role in the formation of these lines.<sup>4–6</sup> We performed corneal topographic examination and Schirmer testing in patients with the Hudson–Stahli line to assess the corneal surface contour and tear secretion in their eyes.

## Subjects and methods

We performed the study in two parts. In part I, we enrolled 50 patients aged 40 years or more, in whom slit-lamp biomicroscopy revealed the presence of a Hudson–Stahli line in both eyes. Exclusion criteria included corneal disease, previous ocular surgery, long-term use of ocular medication, and contact lens use. We also enrolled 55 age-matched controls, who did not have the Hudson–Stahli line in either eye. All patients signed an informed consent.

After routine ophthalmic evaluation, cases and controls underwent keratometry (Shin–Nippon, Tokyo, Japan), corneal topography (TMS-2 videokeratoscope, Computed Anatomy, New York), and Schirmer testing. Data from the right eye of cases and controls were used for analysis. The topographic map (absolute scale) was classified as round, oval, symmetric bowtie, asymmetric bowtie or irregular.<sup>7</sup> The surface regularity index (SRI) and the surface asymmetry index (SAI), from the topographic map, were noted. Schirmer testing was performed in a dimly lit room

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**Table 1** Test results in cases and controls (part I of the study)

	Cases	Controls
Keratometry (mean $\pm$ SD)		
Vertical meridian*	43.01 $\pm$ 2.01 D	43.94 $\pm$ 1.78 D
Horizontal meridian	43.75 $\pm$ 5.35 D	44.50 $\pm$ 1.83 D
Corneal videokeratography		
Surface regularity index** (mean $\pm$ SD)	0.69 $\pm$ 0.22	0.80 $\pm$ 0.39
Surface asymmetry index (mean $\pm$ SD)	0.38 $\pm$ 0.19	0.45 $\pm$ 0.35
Schirmer test*** (mean $\pm$ SD)	16.72 $\pm$ 4.99 mm	12.57 $\pm$ 3.62 mm

\* $P = 0.01$ ; \*\* $P = 0.054$ ; \*\*\* $P < 0.01$ .

using standard 35-mm strips, without topical anesthesia. The strip was placed in the lower conjunctival cul-de-sac at the junction of the middle and outer one-third of the lower lid. The extent of wetting of the strip was measured at the end of 5 min. In part II of the study, 21 patients with unilateral Hudson–Stahli line were studied. Exclusion criteria and study methodology were similar to that described for part I of the study.

The *t*-test was used to compare the mean Schirmer values, of cases and controls in part I of the study, and in the right and left eyes of subjects, in part II of the study.

## Results

### Part I of the study

The average age of the 50 cases (22 males, 28 females) was  $57.9 \pm 9.7$  years (range 40–83 years). This was not different from the mean age of the 55 controls (32 males, 23 females),  $59.12 \pm 11.52$  years (range 42–85 years). The results of keratometry, corneal topography and Schirmer testing in cases and controls are described in Table 1. Mean horizontal keratometry and SAI values were similar in cases and controls. Vertical keratometry in cases ( $43.02 \pm 2.01$ ) was less than that in controls ( $43.94 \pm 1.77$ ) ( $P = 0.01$ ). The surface regularity index in controls was greater, indicating a more irregular surface, with the difference approaching

statistical significance ( $P = 0.054$ ). No distinct corneal topographic pattern was observed in the cases. The mean Schirmer value in cases ( $16.72 \pm 4.99$  mm, range 10–30 mm) was significantly greater than that in controls ( $12.57 \pm 3.62$  mm, range 5–25 mm) ( $P < 0.01$ ).

### Part II of the study

The average age of the 21 subjects (eight males, 13 females) was  $61.8 \pm 10.3$  years (range 45–90 years). The results of keratometry, corneal topography, and Schirmer testing in the right and left eye of the study group are described in Table 2. Mean horizontal and vertical keratometry, SRI and SAI values were similar in fellow eyes of patients. No distinct corneal topographic pattern was observed in eyes with the Hudson–Stahli line. The mean Schirmer value in eyes with the Hudson–Stahli line ( $17.52 \pm 6.86$  mm, range 5–30 mm) was significantly greater than that in eyes without ( $13.67 \pm 4.64$  mm, range 5–22 mm) ( $P = 0.04$ ).

### Comment

Corneal epithelial pigment lines, similar to the Hudson–Stahli line, have also been described in other corneal conditions—keratoconus (Fleischer ring), filtering bleb (Ferry line); pterygium (Stocker line), in association with corneal scars, and after penetrating keratoplasty.<sup>3</sup> Recently, such lines have been described after a variety of corneal refractive procedures.<sup>4–6</sup>

**Table 2** Test results in fellow eyes of subjects with unilateral Hudson–Stahli line (part II of the study)

	Eye with Hudson–Stahli line	Eye without Hudson–Stahli line
Keratometry (mean $\pm$ SD)		
Vertical meridian	44.84 $\pm$ 1.27 D	44.66 $\pm$ 1.43 D
Horizontal meridian	44.91 $\pm$ 1.29 D	44.95 $\pm$ 1.29 D
Corneal videokeratography		
Surface regularity index (mean $\pm$ SD)	0.88 $\pm$ 0.32	0.78 $\pm$ 0.22
Surface asymmetry index (mean $\pm$ SD)	0.47 $\pm$ 0.23	0.47 $\pm$ 0.28
Schirmer test* (mean $\pm$ SD)	17.52 $\pm$ 6.86 mm	13.67 $\pm$ 4.64 mm

\* $P = 0.04$ .

Although it has been suggested that all of these iron lines are identical histologically and histochemically,<sup>8,9</sup> the exact source and mechanism of iron deposition in the corneal epithelium are yet to be determined. The reason for the variation in corneal location of these lines is also not clear.

In 1964, Gass<sup>2</sup> suggested that iron from various sources, including tears, is deposited within the basal epithelial cells of the cornea causing pigment lines. This report has produced the tear pool hypothesis, according to which altered corneal topography results in localized tear pooling. The sequestered tear film iron accumulates in the basal epithelial cells that lie beneath the pooled tear layer, producing localized iron lines in the cornea. The Hudson–Stahli line is therefore, thought to result from eyelid-blink associated tear pooling.<sup>3</sup>

In 1987, Rose and Lavin<sup>1</sup> proposed the basal cell migration theory, in which they suggested that iron deposition might be modulated by surface epithelial cell turnover. They hypothesized that surface epithelial cell attrition is greatest in the lower two-thirds of the cornea, with increased basal cell mitoses and a decreased rate of basal cell migration. The population of rapidly dividing, nonmigrating basal cells would therefore, become relatively mature. Iron accumulation in these cells, with time, would result in the characteristic pattern of iron deposition.

More recently, Assil *et al*<sup>5</sup> have suggested a modification of the existing hypotheses for corneal epithelial pigment formation, based on their study of these lines in eyes with corneal intrastromal ring implantation. They proposed that tear desiccation in certain zones results in an increased concentration of soluble iron. When this tear breakup occurs in areas with diminished cell turnover rates, iron accumulates in the basal epithelial cells of the cornea. They hypothesized that the junction of the upper two-thirds and lower one third of the cornea is prone to tear film instability, and represents a zone of senescent corneal epithelial cells. They thus, proposed that these two factors are responsible for the formation of the Hudson–Stahli line.

Both factors described in the above hypothesis are present in humans, from birth. Although the Hudson–Stahli line has been described in children,<sup>2</sup> it mostly occurs after the fifth decade.<sup>10</sup> The reason for this delayed occurrence of the Hudson–Stahli line is not clear, especially since pigment lines form as early as 6–12 months after surgical alteration of corneal topography.<sup>4–6</sup> Abrupt alterations in the normal prolate corneal shape therefore, seem to hasten the deposition of iron in basal epithelial cells in certain areas of the cornea.

Since the corneal epithelium is constantly renewed every 7–10 days,<sup>11</sup> the concept of the senescent cell seems unlikely. It has also been shown that pigments are present in the basal epithelium throughout the corneal surface,<sup>2,12</sup> implying that they are a normal component of this layer. The existing hypotheses also do not explain the disappearance of corneal pigment within 3 months after removal of the intrastromal corneal ring.<sup>5</sup>

Finally, since tear film desiccation and cell senescence in the interpalpebral cornea are expected in all eyes, the variable occurrence of the Hudson–Stahli line is hard to explain. The line is seen in 29–90% of persons aged 60 years or more.<sup>2,10,13</sup> The unilateral occurrence of the Hudson–Stahli line, in 57% of 287 subjects in a recent study,<sup>14</sup> also indicates that there are as yet unexplained factors that influence formation of corneal pigment lines.

Our study did not detect a specific corneal topographic pattern in eyes with the Hudson–Stahli line, compared to controls. We are not clear about the significance of increased vertical keratometry values in controls in part I of the study. There was no significant difference in keratometry values in fellow eyes of patients with unilateral Hudson–Stahli line. There was however, significantly greater tear secretion in eyes with the Hudson–Stahli line, as measured by the Schirmer test. We chose not to use topical anesthesia for the test, as studies have shown that an anesthetized ocular surface reduces tear flow dramatically,<sup>15</sup> resulting in an unphysiological situation. A reduction in Schirmer test values with increasing age has been documented previously.<sup>15</sup> A study of 72 subjects aged 10 years or older, revealed a mean Schirmer value of  $16.61 \pm 10.72$ .<sup>16</sup> Although the values declined significantly with age, a sharp decline was noted after the sixth decade. Studies on the epidemiology of the Hudson–Stahli line,<sup>1,13</sup> have indicated that there is a small decline in the incidence of the line in the eighth and ninth decades. This may be due to the steep decline in tear secretion in the elderly and corroborates our finding of reduced tear secretion in eyes without the Hudson–Stahli line.

The surface regularity index, was greater in eyes of controls in part I of the study, although the difference did not attain statistical significance ( $P = 0.054$ ). Reduced tear secretion is one cause of increased corneal surface irregularity and corroborates the results of Schirmer testing indicating reduced tear secretion in these eyes. However, the SRI values were not different in fellow eyes of patients, in part II of the study.

In conclusion, while the exact etiopathogenesis of the Hudson–Stahli line is still unclear, our study indicates

that a normal tear film may be essential for the formation of these lines.

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