

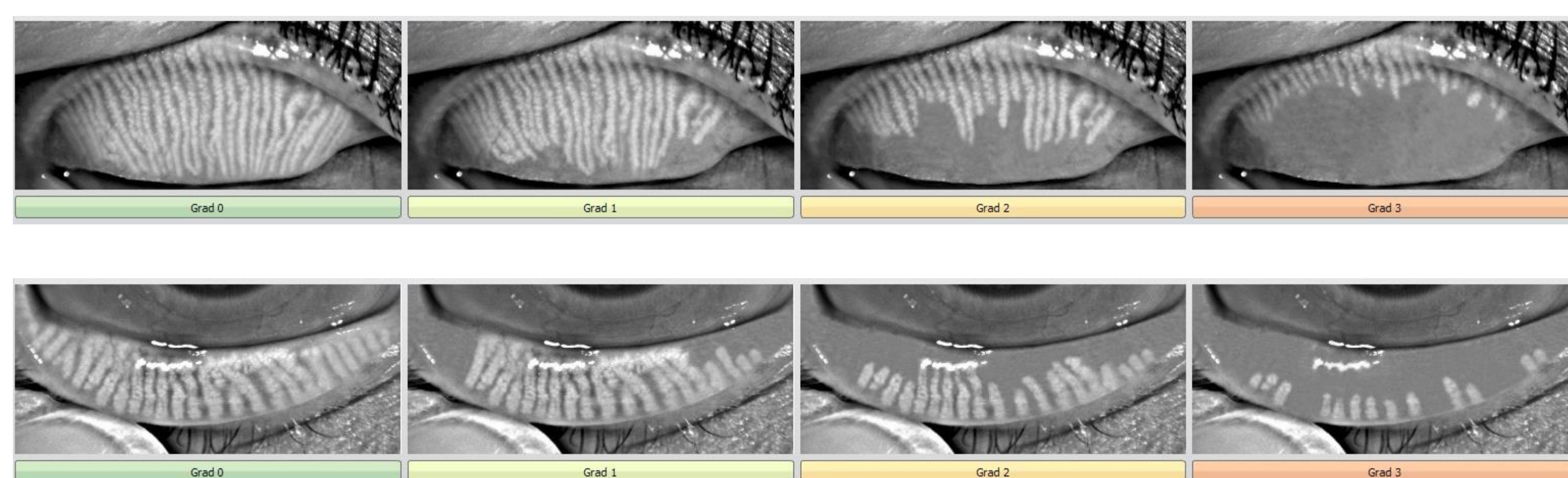
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## Introduction:

Meibomian glands (MGs) are sebaceous glands that are not associated with a hair follicle. They are located within the tarsal plate of the eyelids and differ in length by location (range: 1.9 to 4.8 mm). The number of MGs ranges from 25 to 40 in the superior eyelid and from 20 to 30 in the inferior eyelid [1]. The oil released from the MGs is essential to maintain tear surface tension and tear film thickness, and create an optically smooth surface [2].

It is known that decreased tear film stability contributes to discomfort and decreased vision. JENVIS Research has visualized the classification of MGs according to Arita et al [3] in order to allow a differentiation of MGs regarding their length and quantity. However, the appearance of tortuous MGs is rarely reported. The grade of tortuosity is determined by the degree of “curved” or “twisted” MGs, rather than their degree of atrophy or loss.



**Figure 1:** Subjective Grading of MG atrophy [4]

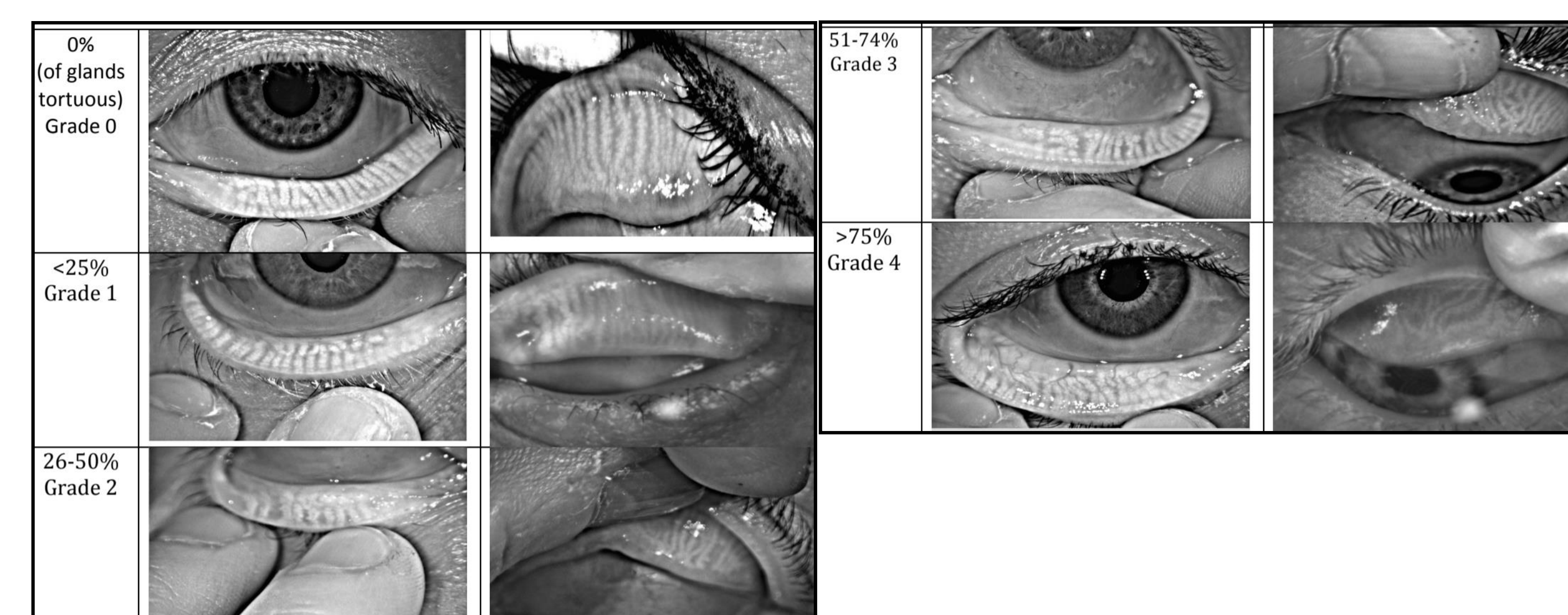
## Purpose:

The etiology of MG tortuosity (deviated glands) is unknown, but it may be caused by chronic terminal duct obstruction or by genetic predisposition. The purpose of this study was to determine if MG tortuosity impacts successful contact lens (CL) wear and if the degree of tortuosity was associated with other signs or symptoms of ocular dryness.

## Methods:

This five-site case-control study recruited subjects between 18 and 45 years of age. Cases had ceased CL use within the past 6-12 months due to discomfort, while age- and sex-matched controls were able to comfortably wear CLs for  $\geq 8$  hours/day for  $\geq 5$  days/week. Each subject was administered a study-specific CL questionnaire and a SPEED questionnaire.

Clinical testing included non-invasive tear break-up time (NITBUT), tear meniscus height (TMH), MG expressibility, meibum quality, and meibography (OCULUS Keratograph 5M). MG tortuosity for each eyelid was graded using the 5-point Halleran scale (Grade 0: no tortuosity; Grade 4:  $\geq 75\%$  of visible MG being tortuous) [5]. Worse eyes (determined by worse eye for tortuosity) comparisons were made with paired t-tests (means) or McNemar’s test (frequencies).



**Figure 2:** Subjective Grading of MG tortuosity [5]

**Table 1:** Ocular Factors by Subject Group

Test	Contact Lens Wearers Mean $\pm$ SD	Contact Lens Dropout Mean $\pm$ SD	P-Value
SPEED Score (units)	2.62 $\pm$ 2.66	6.42 $\pm$ 4.96	<0.001
Diagnosed Dry Eye	0.05 $\pm$ 0.23	0.32 $\pm$ 0.47	<0.001
Non-Invasive Tear Break-Up Time (seconds)	12.33 $\pm$ 8.14	11.36 $\pm$ 8.61	0.41
Tear Meniscus Height (mm)	0.30 $\pm$ 0.10	0.28 $\pm$ 0.10	0.24
Blepharitis			
Upper Eyelid (0-4 scale)	0.46 $\pm$ 0.66	0.71 $\pm$ 0.83	0.09
Lower Eyelid (0-4 scale)	0.20 $\pm$ 0.52	0.38 $\pm$ 0.65	0.09
Number of Plugged Meibomian Glands			
Upper Eyelid (0-3 scale)	0.64 $\pm$ 0.82	1.24 $\pm$ 1.01	<0.001
Lower Eyelid (0-3 scale)	0.71 $\pm$ 0.93	1.06 $\pm$ 1.00	0.04
Meibum Quality			
Upper Eyelid (0-4 scale)	0.66 $\pm$ 1.00	1.37 $\pm$ 1.53	<0.001
Lower Eyelid (0-4 scale)	0.68 $\pm$ 1.15	0.94 $\pm$ 1.20	0.26
Meibomian Gland Atrophy (Meiboscore)			
Upper + Lower Eyelid (0-6 scale)	2.13 $\pm$ 0.66	2.22 $\pm$ 1.05	0.57
Upper Eyelid (0-3 scale)	1.02 $\pm$ 0.30	1.05 $\pm$ 0.49	0.64
Lower Eyelid (0-3 scale)	1.11 $\pm$ 0.59	1.16 $\pm$ 0.76	0.66
Meibomian Gland Tortuosity			
Upper + Lower Eyelid (0-8 scale)	2.32 $\pm$ 1.21	2.53 $\pm$ 1.34	0.36
Upper Eyelid (0-4 scale)	1.41 $\pm$ 0.76	1.85 $\pm$ 1.10	0.01
Lower Eyelid (0-4 scale)	0.91 $\pm$ 0.75	0.69 $\pm$ 0.66	0.04

## Results:

56 matched-pairs were recruited across sites. The mean  $\pm$  SD age of the cases (28.5  $\pm$  7.1 years) and controls (28.6  $\pm$  7.0 years) were not significantly different ( $p = 0.66$ ).

MG tortuosity in control subjects with grade 2 or higher tortuosity was seen in 50% of the upper eyelid and 20% in the lower eyelid. The same intensity of MG tortuosity in dropout subjects was detected in 62% of the upper eyelid and 9% in the lower eyelid.

The cases had significantly higher SPEED scores than the controls (6.42  $\pm$  4.96 vs. 2.62  $\pm$  2.66;  $p < 0.001$ ). Cases did not have significantly higher upper (2.13  $\pm$  1.09 vs. 1.80  $\pm$  0.96;  $p = 0.07$ ), lower (0.82  $\pm$  0.64 vs. 1.00  $\pm$  0.74;  $p = 0.12$ ) or total (2.97  $\pm$  1.30 vs. 2.80  $\pm$  1.29;  $p = 0.39$ ) eyelid tortuosity scores than controls. Tortuosity was significantly associated with TMH ( $p = 0.02$ ), MG expressibility of upper ( $p = 0.03$ ) and lower eyelids ( $p = 0.01$ ) but not SPEED, NITBUT, meibum quality, or MG atrophy (all  $p \geq 0.14$ ).

## Conclusion:

At least some degree of MG tortuosity was commonly noted in both groups of subjects in the upper and lower eyelids. While tortuosity may not be a risk factor for CL dropout, tortuosity is potentially a sign of decreased MG health. Tortuosity may result in altered tear lipid production, which could result in the decreased meibum expressibility and reduced tear volume noted in this study.

## References:

- Knop N, Knop E: Meibom-Drüsen Teil 1, Ophthalmologie 2009, 106:872-883, DOI 10.1007/s00347-009-2006-1 Springer Medizin Verlag
- Knop N, Knop E, Schirra F: Meibom-Drüsen Teil 2, Ophthalmologie 2009, 106:884-892, DOI 10.1007/s00347-009-2019-9 Springer Medizin Verlag
- ARITA, R., K. ITOH, K. INOUE und S. AMANO, 2008. Noncontact infrared meibography to document age-related changes of the meibomian glands in a normal population [online]. Ophthalmology, 115(5), 911-915, DOI 10.1016/j.ophtha.2007.06.031.
- Ahrentschildt A, Wittkind J, Marx S, Sickenberger W: Comparative study of two grading scales for the evaluation of IR-meibography images of the upper and lower eyelid in terms of intra- and interrater reliability. Poster AAO Congress 2018 in San Antonio
- Halleran C, Kwan J, Hom M, Harthan J: Agreement in Reading Centre Grading of Meibomian Gland Tortuosity and Atrophy. Poster AAO Congress 2016 in Anaheim

## Acknowledgements:

The study was funded by Alcon Research, Inc. through an Investigator Initiated Study.