Contact Lens Update

CLINICAL INSIGHTS BASED IN CURRENT RESEARCH

In vivo 3D meibography of the human eyelid using real time imaging Fourier-Domain OCT

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Meibomian glands are modified sebaceous glands in both upper and lower lids that secrete meibum onto the pre-ocular tear film. Obstruction and/or qualitative/quantitative changes in the glandular secretion of these glands are signs found in meibomian gland dysfunction (MGD),[1] which is commonly associated with the signs and symptoms observed in dry eye patients.

Imaging of meibomian glands has developed significantly over the years, from lid trans-illumination techniques that were uncomfortable for the patient, to real-time imaging of the glands by means of non-contact meibography using infra-red light or anterior segment optical coherence tomography (AS-OCT). While non-contact meibography provides two-dimensional en face images of the glands, AS-OCT allows the acquisition of multiple serial tomograms (B-Scans) of the tarsal plate that can then be used for 3D reconstruction of the meibomian glands.

Hwang HS, Shin JG, Lee BH, Eom TJ, Joo C-K (2013) In vivo 3D meibography of the human eyelid using real time imaging Fourier-Domain OCT. PLoS ONE 8(6): e67143. doi:10.1371/journal.pone.0067143

In a recent paper[2], Hwang et al. describe the development of a Fourier-Domain OCT (FD-OCT) imaging system that allows in vivo acquisition of serial tomograms and subsequent 3D reconstruction of meibomian glands.

Meibomian gland imaging and 3D reconstruction

The upper eyelids of nine participants (seven MGD patients and two healthy controls) were imaged using both non-contact infrared meibography and a real-time Fourier-Domain OCT (FD-OCT) imaging system. The customized non-contact meibography system consisted of a slit lamp biomicroscope with an attached infrared filter, which only transmitted light above 720nm; images were obtained at 10x and 25x magnification.

The real time imaging FD-OCT system was based on a high-speed wavelength swept laser with spectral bandwidth of 100 nm at 1310 nm center wavelength; axial and lateral resolution of the system were 5 µm and 13 µm, respectively.

OCT images were obtained by repeating the A-scans twice (in order to enhance the image quality) prior to performing B-scans (500 A-scans) and C-scans (200 B-scans); B-scans were 700 x 500 pixels and C-scans were 700 x 500 x 200 voxels.

The scan range for each image was 5mm (B-scan; left to right) x 2mm (C-scan; upper to lower part of the palpebral conjunctiva). 3D images of the meibomian glands were reconstructed from the serial tomograms using 3D “data visualization, analysis and modeling software”.

Results

Figure 1 shows an example of a reconstructed 3D-iamge for a healthy control subject. The morphology of the meibomian glands as visible in the reconstructed 3D meibography images in both MGD patients and healthy controls was consistent with the images obtained with the current standard imaging procedure, non-contact infrared meibography. In some cases, 3D reconstruction from the FD-OCT meibography images provided information that was not visible from the en face non-contact meibography images. An example of this is shown in Figure 2, where extensive branching structures of neighbouring meibomian glands are visible in the 3D reconstructed FD-OCT image (top) but not in in the non-contact meibography image (bottom).

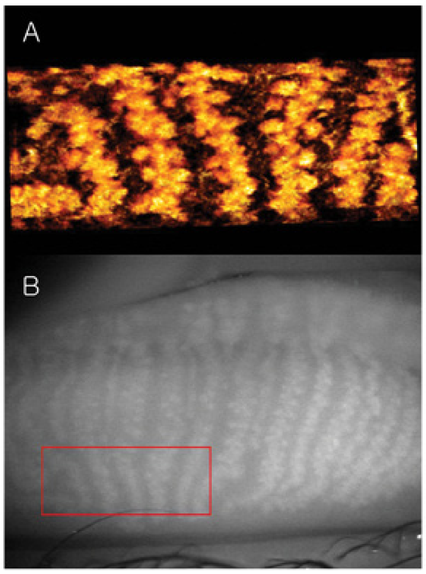

Figure 1 (Figure 6 in original paper[3])

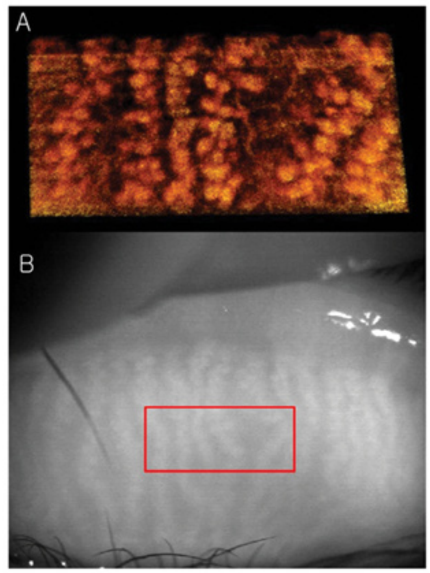

Figure 2 (Figure 7 in original paper[4])

Discussion and conclusions

Meibomian gland structures, including the gland duct and acini, were clearly visible from the reconstructed 3D images, which also showed the parallel arrangement of meibomian glands. The authors explained the successful imaging and reconstruction of 3D images of the glands with two major features of their system, (1) the high-speed imaging capabilities of the FD-OCT, reducing the effect of lid motion artefacts, and (2) its wavelength of 1310nm, allowing a deep penetration into the palpebral conjunctival tissue and therefore the visualisation of the meibomian glands.

Although this customized FD-OCT imaging system was used in a research setting, it may also be beneficial for more clinical applications. Since the reconstructed 3D images include depth information that is not available in en face 2D infrared meibography images, they provide more detailed morphological information than infrared meibography. This may allow further classification of MGD into types (obstructive or hyposecretory) or the detection of e.g. early atrophic changes to the gland acini in early stages of MGD. Furthermore, it may be possible to derive novel parameters such as acinus or central duct diameter from analysis of the 3D images, which may assist in gaining a better understanding of dry eye or MGD.

The small imaging field (5x2mm) relative to the size of the palpebral conjunctiva represents a shortcoming of the FD-OCT imaging system, making the selection of the scan location crucial for assessment of meibomian glands. Therefore, using the novel FD-OCT imaging system in conjunction with en face infrared non-contact meibography may be commendable for getting a better understanding of MGD.

REFERENCES:

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2. Hwang HS, Shin JG, Lee BH, et al. In vivo 3D meibography of the human eyelid using real time imaging Fourier-Domain OCT. PLoS One 2013;8:e67143.
3. Figure 6 in Hwang HS, Shin JG, Lee BH, et al. In vivo 3D meibography of the human eyelid using real time imaging Fourier-Domain OCT. PLoS One 2013;8:e67143 retrieved on Feb. 24, 2014 at www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0067143;jsessionid=12FDAF6D7673790FD3482045E161F8CE.
4. Figure 7 in Hwang HS, Shin JG, Lee BH, et al. In vivo 3D meibography of the human eyelid using real time imaging Fourier-Domain OCT. PLoS One 2013;8:e67143 retrieved on Feb. 24, 2014 at www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0067143;jsessionid=12FDAF6D7673790FD3482045E161F8CE.