“LEVELLING THE EYE”

to provide a more accurate ocular shape for comparative analysis and contact lens fitting

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INTRODUCTION

Topography maps play an important, increasing role in contact lenses design and fitting, particularly for large diameter lenses.

Whenever an eye is measured using a topography machine, the fixation point is required to be in the machine head, around 2 to 10 cm in front of the eye.

This practice induces rotation of the eye which can result in tilted maps, affecting measurement accuracy. Additionally, this measurement is necessarily around the visual axis whereas the geometric axis is more important for ocular shape measurements

It is not a simple matter to compensate for this induced error, as the eye itself has few, if any, identifiable characteristics to facilitate correct orientation.

This study developed methodologies to level the eye topography data around its geometrical axis, thus providing more accurate information regarding ocular shape.

METHODS

Topography data were collected from three different machines; Pentacam, Galillei G6 and the Eye Surface Profiler (Eaglet Eye Netherlands). Height data were exported in coma separated file format (CSV) and then used as input files for a custom built Matlab code to be processed.

The levelling process uses two different approaches to level the surfaces according to the topography machine collecting them.

For Pentacam and Galilei G6, a first order Zernike polynomial is fitted to the front surface of the cornea and eye height data rotated until the Zernike plane is horizontal.

For the ESP, the limbus was detected using the tangent angles and the all limbal points fitted to a plane which is rotated until it becomes horizontal.

The final levelled eye position was then compared to the software output of commercial topography machines.

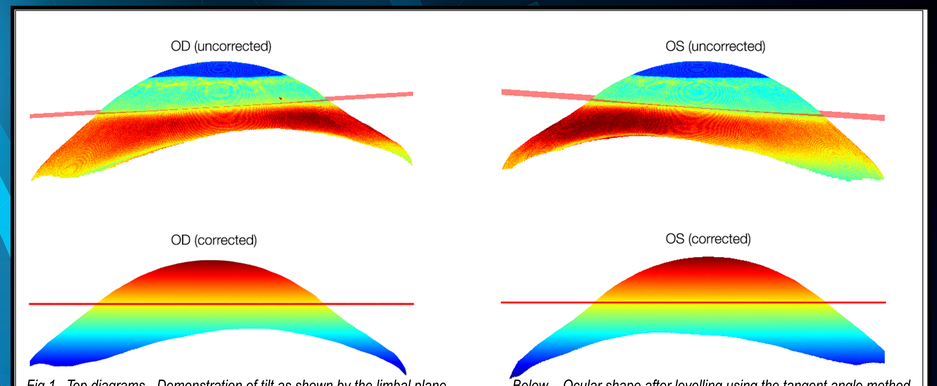

Fig 1 Top diagrams - Demonstration of tilt as shown by the limbal plane Below – Ocular shape after levelling using the tangent angle method. It can be seen that the appearance of nasal flattening is much reduced after levelling.

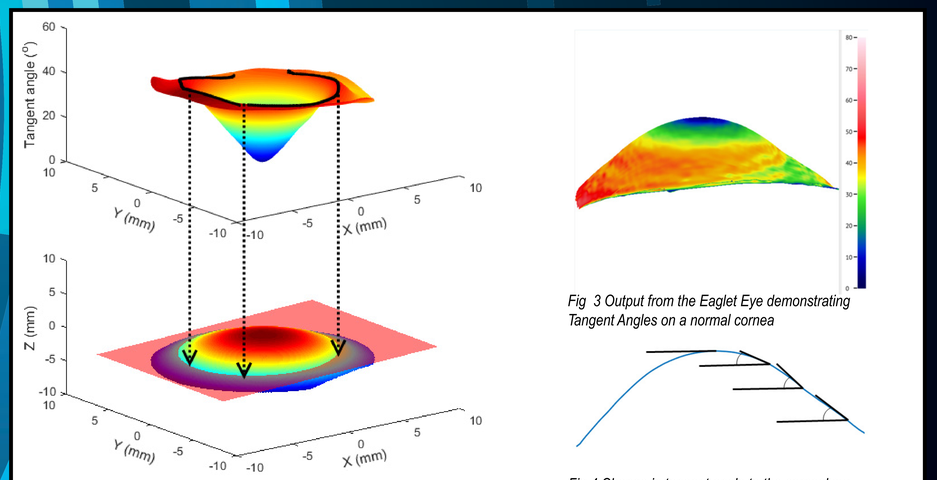

Fig 2 Tangent angle changes are mapped onto the corneal surface

Fig 3 Output from the Eaglet Eye demonstrating Tangent Angles on a normal cornea

Fig 4 Change in tangent angle to the corneal surface indicates the limbal location

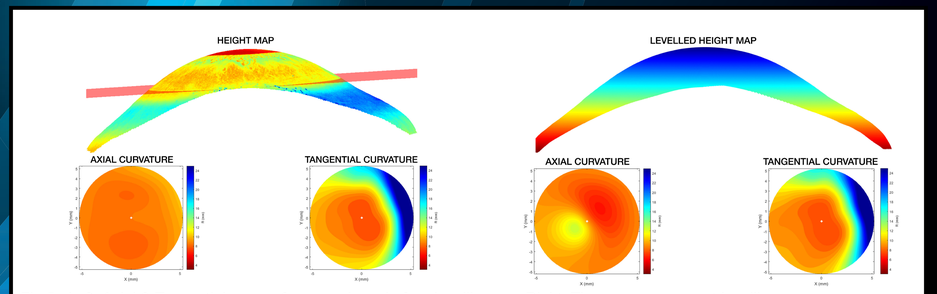

Fig 5 Left: Axial & Tangential maps of a normal eye before levelling Right: The same maps post levelling. It can be seen that the tangential map is least affected by tilt and is therefore a more reliable system.

RESULTS

Comparing final levelled eye positions and maps to those of commercial topography machines show that maps based on Axial or Sagittal topography are very sensitive to tilt. Additionally, they are not fully representative of actual ocular shape, particularly in the mid peripheral regions.

However, Tangential maps are much less sensitive to tilted geometry and give a much more representative overview of real eye shape.

For keratoconic patients, the study also showed that tangential maps are the most representative maps in identifying the cone position.

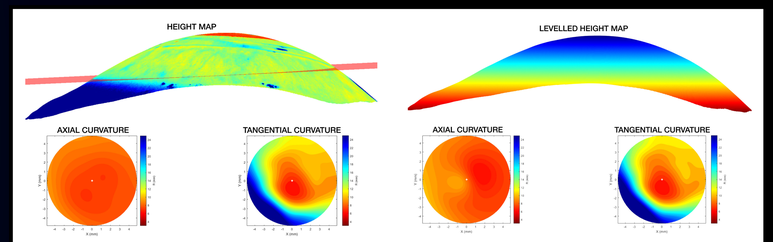

Fig 6 Left: Axial & Tangential maps of a keratoconic eye before levelling Right: The same maps post levelling.

It can be seen that the Axial map is severely affected by tilt but there is hardly any change to the tangential map, making it much more useful for lens fitting.

CONCLUSIONS

Tilted topography maps can be misleading and affect both contact lens fitting and the design of new lens products. This tilting effect is a natural consequence of the position of the retinal fovea/visual axis.

This study has shown that levelling the eye is possible using first order Zernike polynomial fit or limbus detection technique based on tangent angle mapping.

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