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An observational cross-sectional study on the corneal endothelium of medium-term rigid gas permeable contact lens wearers

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ABSTRACT

Purpose: To assess if polymegethism and pleomorphism were evident in corneal endothelium after medium-term rigid gas permeable (RGP) contact lens wear.
Methods: In a cross-sectional observational study over 12 years, single images of the central region of the corneal endothelium of one eye of 46 subjects were taken with a non-contact specular microscope, along with a measure of central corneal thickness (CCT). The images were printed onto A3-sized paper and 100 cells/image measured by planimetry.
Results: Subjects aged between 20 and 32 years, with an average cumulative RGP wear of 6.0 +/− 1.6 years (range 3–9 years) were assessed; 26 of the subjects were Caucasian and 20 were Asian. The mean CCT was 0.515 +/− 0.027 mm. The group cell area value was 401 +/− 42 sq micron to give an estimated endothelial cell density (ECD) of 2520 +/− 273 cells/sq mm. As compared to a historical database, most endothelia (37/46) showed some changes with the mean coefficient of variation on cell area (COV) being 36.7 +/− 8.0% and the percentage of 6-sided (HEX) being 51.8 +/− 8.8%. There were modest correlations between years of RGP wear and both COV ($p = 0.009$, r spearman = 0.424) and HEX ($p = 0.025$, r spearman = −0.291), but not for ECD or CCT.
Conclusions: Corneal endothelial polymegethism appears to be a commonplace consequence of RGP lens wear with the magnitude of the change being related to the cumulative duration of the lens wear.

1. Introduction

As viewed *in vivo* by specular microscopy, the corneal endothelium of the young healthy adult appears remarkable in being composed of cells with uniformity in size and shape [1,2]. The cell size, as reported in the vast majority of endothelial assessments, is given as the endothelial cell density, or ECD, in cells/mm^2. The uniformity of the cell mosaic is less commonly assessed, but where undertaken has been described by calculations of the coefficient of variation in cell area (usually referred to as the COV, CV or polymegethism index) and the relative numbers of 6-sided cells (usually referred to as the hexagonality or HEX measure) [3]. For healthy young adults (e.g. aged between 20 and 40 years of age) who were not contact lens wearers but of different ethnic groups, early publications on endothelial morphometry over nearly a 20 year period indicated that the COV values would likely be between 25 and 30% and the percentage of 6-sided cells between 60 and 70% [4–14]. Such reports provided a basis for a recognition, over the same time period, that such an apparently uniform mosaic was not always evident.

It was long ago recognized that contact lens wear could result in the development of remarkable non-uniformity to the endothelial mosaic, with the appearance of substantial polymegethism (increased variation in cell areas) and pleomorphism (reduced percentage of 6-sided cells) [15]; this was evident if polymethylmethacrylate (PMMA) lenses were worn with effect being attributed to the very limited oxygen permeability of these lenses. With the advent of contact lens materials with higher oxygen permeability (e.g. rigid gas permeable, RGP lenses) it might be expected that long-term lens-wear-associated polymegethism of the corneal endothelium would be less or not even evident.

In early years of assessments of RGP lens wear and the corneal endothelium, a number of small scale studies (less than 20 eyes), and mostly after only 1 year of RGP lens wear concluded that substantial polymegethism was not evident [14,16–21]. However, one prospective study did report that while the average COV after 1 year of RGP lens wear (without prior contact lens wear) was only 31%, COV values as high as 40% could be seen in some individuals

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[16]. Similarly, another prospective study of 13–19 subjects over 3 years indicated that there was a progressive increase in COV to an average of 31 ± 6% [14]. However, a more recent report from two USA sites, that included data from a cross-sectional analysis of the endothelia (by non-contact specular microscopy) of subjects recruited into a continuous wear trial [22], noted a prior history of RGP lens wear averaging 19.7 ± 9.7 years and that these 21 subjects had an average COV of 40.14 ± 7.04% (mean ± SD), i.e. indicating that most of the RGP lens wearers had COV values above 30%. Some other endothelial studies have been undertaken on RGP lens wearers but have not reported on the COV.

Based on the published studies, there is a lack of information on the corneal endothelium after medium-term wear of RGP contact lenses. With the more recent report indicating rather high average COV values in longer-term RGP lens wearers [22], assessments were started of the endothelia of medium-term RGP lens wearers. These assessments were undertaken over a 12 year as opportunities arose as part of ongoing studies on the human corneal endothelium period. The same imaging capture system (non contact specular microscopy) and image analysis method (pictures enlarged, borders marked and the same number of cells assessed) was used throughout.

2. Subjects and methods

2.1. Subjects and RGP lens wear details

With approval from the university ethics committee, the subjects were recruited on an *ad hoc* basis over a 12 year period by personal contact with undergraduate and especially graduate student classes who were asked if anyone was an RGP lens wearer and would mind having their cornea assessed by the author. Subjects were advised that the image acquisitions would be anonymous, and provided written consent. The Glasgow-Caledonian University Ocular Comfort Questionnaire [23] was completed by almost all subjects (41 of 46), and included a blank visual analogue scale (VAS) where the subjects were asked to indicate their comfort from 'Uncomfortable' to 'Comfortable' with a vertical line. The distance on a 100 point scale (not included) was then measured. The questionnaire also included questions on gender, ethnic origin and the students self-reported refractive error, years of RGP contact lens wear (with a check made that no soft contact lenses had been used and that no refractive surgery had been undertaken) and medicines use. Depending on time available and interest from the students, the investigator also tried to obtain information on the actual lens being worn but this generally proved to be rather unproductive as a history of more than one RGP lens type was reported by many of the subjects (see Results).

2.2. Endothelial image acquisition

Single images of the central region of the corneal endothelium were used from one eye of each subject. These images were mostly taken with the Topcon SP-3000P instrument, but a few earlier subjects were evaluated using the previous SP-2000P model, with both instruments being used in auto-focus mode and having the same internal calibration scale. In both cases, the specular microscope was linked to a thermal paper printer (Sony Videographic Printer, model UP-897) which was also routinely used to capture an image of the external eye. As the image, especially the eyelid margins, was brought into focus using the joystick control, the printer was manually activated and produced a reasonable resolution photograph of the external eye at a nominal 4× magnification (Fig. 1). This was principally used to judge whether or not the horizontal corneal diameter (HCD) was within normal limits [24], but also provides a gross assessment of external eye appearance. This included whether or not any obvious hyperaemia (injection) of the bulbar conjunctiva was evident, the uniformity of the lower tear meniscus, how much reflective material (principally meibum) was present across the lower eyelid marginal zone and also (especially for female subjects) the state of the eyelashes (including how much make up was present). This viewing perspective (as shown in Fig. 1) also allowed for gross assessment of how clean the surface of the contact lens was (especially in the women), and of how mobile the lens was. Taking this first image took quite a bit of patience since the subtle movement of the lens is likely detected by the auto-focus mechanism and the image acquisition (of the endothelium) often took several seconds of careful control of image focussing. This first image, when the auto-focus for the endothelium is activated, also provided pachymetry output of the central corneal region with the RGP lens in place. The subjects were then asked to take their contact lens out and another image of the central region of the endothelium captured. This was usually and easily accomplished at the first attempt and provided an image of numerous cells in clear focus, with a pachymetry output for the cornea without the RGP lens in place.

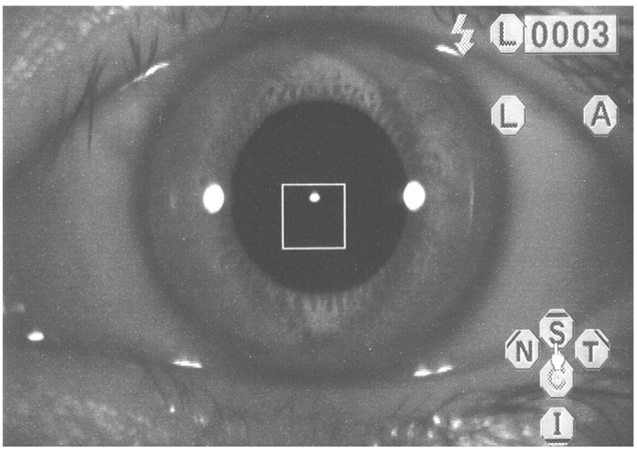

Fig. 1. Example of external eye image captured with SP-3000P specular microscope linked to a thermal printer to show RGP lens in place.

2.3. Image processing

All image processing was undertaken by the author. After attaching a number code ID to the prints, these were assessed by manual cell border marking and planimetry essentially as previously detailed [24]. 100 cells/image were marked (see Figs. 2–4) and their areas measured to within an estimated ± 2% accuracy or better. The number of 6-sided cells (HEX) was also counted.

2.4. Statistical analyses

Using Systat (v. 11, Systat, IL), the average cell area value (in μm^2), the SD and the coefficient of variation (COV, based on SD/average cell area) were calculated, as was an estimate of the endothelial cell density (ECD) based on 1000000/average cell area value. Individual data from each image were then used to calculate global mean values for the set of subjects. Comparisons between output measures were generally made using a Spearman rank order correlation (r_s), but some continuous regression analyses were also undertaken to assess possible inter-dependency of the outcome measures.

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