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Optimal time following fluorescein instillation to evaluate rigid gas permeable contact lens fit

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ABSTRACT

Purpose: To examine the optimum time at which fluorescein patterns of gas permeable lenses (GPs) should be evaluated.
Methods: Aligned, 0.2 mm steep and 0.2 mm flat GPs were fitted to 17 patients (aged 20.6 ± 1.1 years, 10 male). Fluorescein was applied to their upper temporal bulbar conjunctiva with a moistened fluorescein strip. Digital slit lamp images (CSO, Italy) at 10× magnification of the fluorescein pattern viewed with blue light through a yellow filter were captured every 15 s. Fluorescein intensity in central, mid peripheral and edge regions of the superior, inferior, temporal and nasal quadrants of the lens were graded subjectively using a +2 to −2 scale and using ImageJ software on the simultaneously captured images.
Results: Subjectively graded and objectively image analysed fluorescein intensity changed with time ($p < 0.001$), lens region (centre, mid-periphery and edge: $p < 0.05$) and there was interaction between lens region with lens fit ($p < 0.001$). For edge band width, there was a significant effect of time ($F = 118.503$, $p < 0.001$) and lens fit ($F = 5.1249$, $p = 0.012$). The expected alignment, flat and steep fitting patterns could be seen from approximately after 30 to 180 s subjectively and 15 to 105 s in captured images.
Conclusion: Although the stability of fluorescein intensity can start to decline in as little as 45 s post fluorescein instillation, the diagnostic pattern of alignment, steep or flat fit is seen in each meridian by subjective observation from about 30 s to 3 min indicating this is the most appropriate time window to evaluate GP lenses in clinical practice.

1. Introduction

Gas permeable lenses (GPs) were introduced in the late 1970s as an improvement on Polymethylmethacrylate (PMMA) material hard lenses that were impermeable to oxygen. Modern GPs tend to contain silicone and fluorine, resulting in greater flexibility and greater oxygen permeability [1]. Despite this, the International Survey of Rigid Contact Lens Fitting [2] has shown a decline in GP contact lens fits over the past 16 years. Reasons suggested for this decline include the initial lens discomfort, induced corneal pathology (such as 3 and 9 o'clock staining) and lid pathology (ptosis) [3–5]. Modern soft contact lenses on the other hand provide excellent comfort [6] even to patients who have not worn contact lenses before, and daily disposable lenses are very convenient for those who do not have time to clean their lenses. However, GPs still have their place on the market as they generally offer better quality and more stable vision, for example in patients with keratoconus [7] and patients with significant corneal astigmatism, especially if irregular [8,9]. GPs also have a much greater life expectancy than soft contact lenses [9], are healthier than other forms of contact lens wear [10] and need replacing less often [2].

The fit of hard contact lenses have been evaluated using fluorescein since their introduction in the 1950s [11]. It allows the practitioner to "assess the complex interactions between the eye and the lens" [12]. This is not the case with soft contact lenses because they mould to the front surface of the eye so fit needs to be determined by other metrics [13] and fluorescein can be absorbed by the lens matrix, causing discolouration [14].

The evaluation of a GP can be split into two sections; the dynamic fit of the lens, using white light and the fluorescein analysis, assessed using blue light and a yellow barrier filter [11]. According to a recent consensus group, fluorescein fit should be assessed in the primary position (the 'Primary Fluorescein Pattern'), rating the intensity of fluorescein in the central zone (which consists of the inner half of the radius, not including the very centre), mid-periphery (which consists of the outer half of the radius) and the

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edge curve (which is the final band around the edge of the lens) on a scale from +2 to −2, along both the horizontal and vertical meridians [11].

There is currently little research on the amount of time fluorescein remains in the eye after instillation and how this impacts on the observation of the lens fit. A study carried out by Peterson and colleagues (2006) investigated the efficacy of fluorescein in a clinical environment, using a 1% minim, 2% minim, a single drop of saline solution on a fluoret and a fluoret moistened with saline, with the excess shaken off [15]. Their results showed that quenching (when fluorescence is decreased by an excessive depth of fluorescein molecules decreases the vibration of surface molecules excited by the blue light) was present in all methods of fluorescein instillation and within 20 s a moistened fluoret and a 1% minim reached useful fluorescent levels, which lasted for approximately 160 s. This was 2.5 times faster than the saturated fluoret and 2% minim, indicating a 1% minim or a moistened fluoret are the best ways to instil fluorescein for GP fitting. However, the persistence of fluorescein beneath a GP lens to allow evaluation of lens fit has not been investigated and was therefore the aim of this study.

2. Methods

Seventeen patients (aged 20.6 ± 1.1 years, 10 males and 7 females) were recruited for this study whose best spherical component of their spectacle prescriptions ranged between +0.50 DS and −5.50 DS, had ≤0.75 D of astigmatism (the steeper axis was orientated at a meridian between 80° and 100°) and whose eyes were healthy as determined by slit-lamp biomicroscopy examination. The validated Medmont E300 (Camberwell, Australia) corneal topographer was used to quantify the corneal curvature (K readings) of the right eye [16]. The K readings obtained were used to calculate the back optic zone radius of the alignment lens based on the formula: $K_{\text{flattest}} - (K_{\text{flattest}} - K_{\text{steepest}})/3$. From the value calculated for the aligned lens (average 8.02 ± 0.25 mm, range 7.65–8.40 mm), 0.2 mm steeper and flatter lenses (Quasar design from No. 7, Hasting, UK) were also fitted in random order within the hours of 10 am to 4 pm. The base curve step size was selected to encompass the range of fits that might be seen in clinical practice. Following 5 min initial settling time (as the patients were adapted GP wearers), the lens was observed by a masked observer using video slit lamp (CSO SL990 Digital LED Elite, Florence, Italy). The slit lamp was set up at 10× magnification, with its blue light at maximum brightness and slit width, and using the in-build yellow barrier filter in a dark room.

Sodium fluorescein was instilled into the superior temporal conjunctiva with a moistened fluorescein sodium strips (Bioglow, Rose Stone Enterprises, Alta Lorna, CA, USA). A drop of saline was used to moisten the strip and any excess moisture was shaken off [15]. Following the instillation, patients were instructed to blink a couple of times to help distribute the fluorescein.

Based on pilot data on the persistence of fluorescein during subjective and objective imaging and previous findings without GPs in-situ [15], subjective imaging was graded every 30 s over 4 min whereas objective image capture was conducted every 15 s over 2 min. Fluorescein was subjectively graded on a +2 to −2 scale, in the centre, mid-periphery and edge zones of each lens, along both the horizontal and vertical meridians [10].

The intensity of fluorescein was recorded objectively in the same zones as the subjective grading using ImageJ software (NIH.com, USA) on a 256 greyscale 8 bit intensity scale. An acetate template placed in front of the laptop screen was used as a guide to ensure that exactly the same area was analysed in each image. In addition to grading the intensity of fluorescein, the widths of the temporal and nasal fluorescein edge bands were measured using ImageJ following calibration by imaging an object of known size through the same slit-lamp set-up.

Table 1
The time at which fluorescein intensity analysed by subjective grading or by objective image analysis significantly altered for each lens fit, lens meridian and lens region based on subjective grading (N = 17).

Fit	Meridian	Region	Time when significant change in fluorescein intensity (s)	
			Subjective	Objective
Flat	Vertical	Centre	180	60
		Mid-periphery	150	60
		Edge	210	75
	Horizontal	Centre	180	60
		Mid-periphery	150	45
		Edge	210	120
Aligned	Vertical	Centre	90	120
		Mid-periphery	120	90
		Edge	210	>120
	Horizontal	Centre	90	120
		Mid-periphery	120	105
		Edge	210	120
Steep	Vertical	Centre	120	>120
		Mid-periphery	150	>120
		Edge	240	>120
	Horizontal	Centre	120	>120
		Mid-periphery	150	>120
		Edge	240	>120

3. Data analysis

Horizontal (nasal and temporal) and vertical (superior and inferior) data was averaged [11]. The subjectively rated fluorescein intensity was not normally distributed for any of the lens regions with meridian or fit (Kolmogorov–Smirnov $Z < 0.001$), hence repeated measure analysis of variance was conducted with Greenhouse–Geisser correction to compensate for this and post-hoc testing with Bonferroni to account for multiple comparisons. The objectively rated fluorescein intensity was normally distributed for the central ($Z = 0.542$, $p = 0.931$), mid-peripheral ($Z = 0.598$, $p = 0.867$) and edge ($Z = 0.543$, $p = 0.929$) lens regions as was the edge band width ($Z = 0.765$, $p = 0.752$), hence repeated measure analysis of variance was conducted to assessment effect of lens region, meridian (nasal, temporal, superior and inferior), lens fit (flat, alignment or steep) and time (0–120 s in 15 s steps). To detect a difference of 30 s with a standard deviation of 45 s, 80% power was achieved with a sample size of 17 subjects.

4. Results

4.1. Subjective rating

Overall, for the subjectively graded fluorescein intensity (Fig. 1) there was a significant difference with time ($F = 61.052$, $p < 0.001$) and lens region (centre, mid-periphery and edge: $F = 148.309$, $p < 0.001$), but not lens fit (steep, alignment and flat: $F = 0.088$, $p = 0.916$) or meridian (vertical and horizontal: $F = 1.748$, $p = 0.204$). The only significant interactions were between lens region with time ($F = 6.584$, $p < 0.001$) and with lens fit ($F = 28.638$, $p < 0.001$). The time at which fluorescein intensity significantly ($p < 0.05$ with Bonferonni pot-hoc test) altered for each lens fit, lens meridian and lens region is presented in Table 1.

4.2. Objective image analysis

Overall, for the objectively image analysed fluorescein intensity (Fig. 2) there was a significant difference with time ($F = 114.336$,