Driving and vision

Part 11 - Contact lenses and driving

Continuing our series on drivers' vision, **Dr Catharine Chisholm** considers the implications of contact lens wear for driving.
Module 17432, one specialist contact lens point for CLOs, one general CET point for optometrists and dispensing opticians

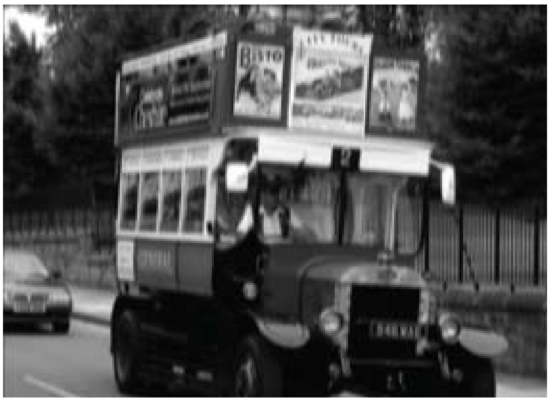

Figure 1 The effect of 0.75DC of uncorrected with-the-rule astigmatism under daylight conditions (Image courtesy of Pedro Serra)

There are an estimated 3.5 million contact lens wearers in the UK, the majority of whom are adults who drive. We can therefore assume that between 5-7 per cent of the driving population wear contact lenses. Previous articles in this series have pointed to the high proportion of drivers that admit to driving with poor vision (20 per cent), and the 10 per cent who do not always wear the spectacles they have been prescribed for distance.[1] Of those surveyed, around a third had not been for an eye examination in the last five years.

Compared to non-wearers, one would expect contact lens wearers to be more aware of the quality of their vision and take action if it deteriorates. The majority are used to attending for aftercare examinations and should develop an understanding of the importance of regular visits to reduce the risks to eye health and ensure that their lenses are meeting their needs. Of course this is a rather rosy view and the reality is that an increasing number of patients buy their lenses online and this is associated with an estimated four-fold increase in the likelihood of 'forgetting' their aftercare schedule.[1]

On average, contact lens wearers visit an eye care practitioner more often, and are therefore more likely to be wearing an up-to-date prescription. There is, however, a tendency for some practitioners to compromise on the contact lens prescription to aid convenience, eg providing lenses of the same power for eyes with slightly differing refractions, so that accidental lens swapping is not a concern. Practitioners need to make sure that vision is not compromised as a result.

For the average patient, the quality of vision provided by a contact lens is comparable to spectacle lenses, both for high contrast visual acuity and contrast sensitivity.[3] This was not necessarily the case before the development of high quality optical designs, frequent replacement lenses and high oxygen transmissibility lenses. Hypoxia resulting in corneal oedema and increased light scatter is almost unheard of with modern lenses.

The visual field remains unrestricted, unlike that associated with small aperture and heavier plastic spectacle frames,[4] which often result in a failure to meet the visual field requirements for a Group 1 driving licence.

Better visual performance leads to quicker reaction times and the ability to assimilate information during rapid scans of the visual scene. Impaired visual performance requires the driver to focus for longer on the object of interest (eg unfamiliar road sign or cyclist), distracting them from other potential hazards within the visual field.

Drivers tend to survey the driving scene predominantly using eye movements in preference to head movements, assuming their optical correction and neck mobility allow. Significant head movements are used in combination with fast saccadic eye movements in situations where rapid gaze-change is required, such as at road junctions or changing lanes in traffic.[5]

Spherical contact lenses generally result in little or no degradation in visual performance with eye movements, as a good fitting lens follows the eye almost exactly. When assessing lens fit, practitioners should consider the degree and speed of horizontal lag in this context, and modify the fit to minimise the lag if vision is likely to be impaired.

There are patient groups for whom contact lenses provide superior visual performance compared to spectacles; high myopes, due to the avoidance of significant spectacle minification, and eyes suffering from corneal irregularity, through the introduction of a smooth refracting surface. Some individuals are only able to meet the driving standard when wearing their contact lenses.

Although contact lenses generally represent a good option for driving, if there is any environment in which minor problems will become evident, it is the visually demanding driving environment. It goes without saying that lens fit should be optimised, not only for the comfort and health of the eyes, but also to ensure clear, stable vision. Poor fitting lenses tend to decentre and if this is substantial, lenses can introduce higher order aberrations such as coma, resulting in image degradation and comet-like tails emanating from lights at night. The lens will also tend to move more, making vision less stable both with blink and on versions.

Uncorrected astigmatism

The most significant cause of substandard vision with contact lenses is the failure to correct small astigmatic errors. Ninety per cent of the population have some degree of astigmatism, with around 15 per cent exhibiting between 0.75-1.00DC. We are taught that small uncorrected cyls may be tolerated in those with low visual demands; those that drive at night do not fall into this category. Few practitioners would consider leaving a 0.75D cyl out of a spectacle correction.

Figure 1 shows the effects of 0.75DC of uncorrected with-the-rule astigmatism, on a real-world image, under photopic (daylight) conditions. Under mesopic conditions (night driving), mild refractive blur becomes all the more significant, having a greater impact on high spatial frequency information.

With modern soft toric lens designs, issues of reproducibility are a thing of the past.[6] Patient and practitioner choice continues to expand with the recent launch of a silicone hydrogel daily disposable toric in the UK. The ease and low cost of neutralising astigmatism with a spherical RGP lens should also not be forgotten. Eye care practitioners really have no excuse for leaving contact lens patients with anything but the smallest degree of uncorrected astigmatism.

Toric lenses now account for around a third of soft lens fits. Maintaining the correct lens orientation is obviously critical when driving. Modern designs have fewer issues with stabilisation but since the lens orientation is dependent on lens-lid interaction, eyes with particularly tight or angled eyelids, or larger oblique cylinders, are less likely to achieve a stable result.

The stability of lens orientation should be assessed in all positions of gaze, not just in the primary position. Rapid, saccadic eye movements are common during driving and some parts of the visual scene involve more extreme positions of gaze, the rear view mirror being the prime example. McIlraith and colleagues[7] examined lens orientation for a range of soft toric lenses in eight directions of gaze. Lenses were found to rotate between 3° and 9° in extreme gaze, with the greatest rotation occurring on superior-temporal (rear-view mirror) and inferior nasal gaze (dash board).

Unpredictable rotation of a toric lens or decentration of a lens can be associated with tear film changes rather than lens fit. The visually demanding nature of the driving task leads to a lower blink rate,[8] and a subsequent increase in the evaporation of the aqueous layer. Humidity within a vehicle is lowered by the use of windscreen blowers and the air that is channelled up from the vents by the windscreen and directed out towards the driver's eyes, further speeding up tear evaporation.

These issues compound the tear film changes associated with longer hours of lens wear and the more demanding nature of night driving, which by definition tends to be undertaken at the end of the day. The result is a thinner pre-lens tear film of greater viscosity. This is often perceived by patients as increased stickiness and they report greater friction between the lens and lid on blink, and a tendency for firm lid blinks to drag the lens upwards and disturb vision.

For the reasons discussed above, dry eye symptoms are much more common when driving. In addition to the well known comfort issues, a poor pre-lens tear film causes a transitory increase in higher order aberrations between blinks.[10] As a result, visual acuity gradually deteriorates until the pre-lens tear film is refreshed by the next blink.[11] In addition, dry patches on the lens can cause an increase in intraocular light scatter and temporarily impair vision. A study of the effects of dry eye on quality of life noted that visually normal dry eye sufferers had difficulty reading road signs and driving at night.[12]

Contact lens compatible tear supplements can provide some relief from symptoms and stabilise vision, but the effects are relatively short lived. Patients should be encouraged to direct ventilation away from their eyes. Sunglasses can also help.

Driving at night

Driving under low illumination is a particularly demanding visual task. Roadside research conducted by the Eyecare Trust found that 53 per cent of those surveyed (n=546) reported difficulty seeing clearly when driving at night. Many objects of interest are close to threshold and sources of glare are numerous (Figure 2). The night-time light levels on our roads in the UK are in the region of 1.0cd/m^2 (high mesopic), resulting in a drop in average acuity from 6/6 to 6/9, associated with neural factors.[12] Performance varies significantly in the mesopic range between individuals, for reasons that are not fully understood. Possible factors include the reduced signal to

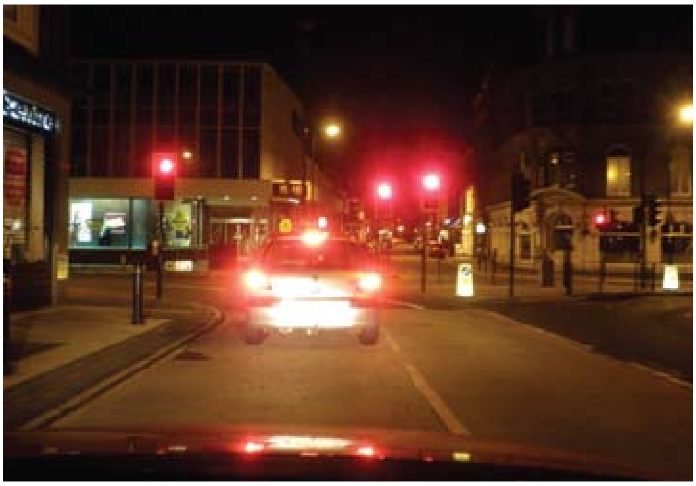

Figure 2 Sources of glare are numerous when driving at night

Figure 3 Distance spectacles result in more eye movements with longer fixations and more error than multifocal contact lenses or monovision

noise ratio and the greater susceptibility to scatter of rod receptors.

The dilated mesopic pupil also has implications for the higher order aberrations of the eye, with an increase in spherical aberration in particular. Any reduction in the optical quality of the eye will influence contrast sensitivity, resulting in some objects of interest falling below the visibility threshold. This is clearly seen in the Australian closed-road driving study undertaken by Wood *et al*,[13] who found that visual impairment reduced the ability of drivers to recognise pedestrians wearing dark clothing on a closed-road circuit. When pedestrians wore reflective markers on their clothing, taking them well above the threshold for seeing, they were identified correctly 80 per cent of the time.

These authors considered how driving was affected by two forms of visual impairment: refractive blur and simulated cataract (matched to refractive blur in terms of visual acuity). A contact lens would never impair contrast sensitivity in the way that cataract does, but the study highlights the importance of assessing contrast vision in addition to visual acuity, something that is not currently a requirement for driving in the UK.

For the vast majority of patients, higher order aberrations under photopic conditions are relatively insignificant. Visual performance may be affected, however, under mesopic conditions as the pupil dilates. For the average patient, positive spherical aberration increases with pupil dilation. Some lenses on the market claim to improve vision by correcting spherical aberration. These lenses have aspheric surfaces and should work by inducing negative spherical aberration to neutralise the average spherical aberration of the population. The amount of spherical aberration induced by any contact lens is dependent on its back vertex power and the surface designs.[14]

Non-customised, 'aberration-free' lenses work well for some individuals but actually make things worse for others by over-correcting spherical aberration.[15] Without access to an aberrometer in practice, practitioners have no way of knowing who will benefit. Patients with large pupils and night vision symptoms are worth trying with such lenses. A spherical lens can be fitted to one eye and an aberration-free lens to the other, while the patient observes differences is the appearance of a discreet LED in a blacked-out test room. A trial that includes night driving may be beneficial for those that report a smaller spread of light around the LED from the 'aberration-free' lens.

Aberrations are most certainly a problem for orthokeratology patients. When an RGP lens is worn overnight to flatten the central cornea and reduce myopia, the corneal reshaping induces significant third- and fourth-order aberrations, primarily coma, spherical aberration and trefoil. In the presence of a mesopic pupil, these aberrations represent a significant deterioration in the optical quality of the eye, with an associated deterioration in mesopic contrast sensitivity, particularly in the presence of glare. In a recent Japanese study 36 per cent of eyes failed to meet the German night driving standard as assessed by the Oculus Mesotest II.[16]

Standard RGP lenses can suffer from flare and halos due to a mismatch between the diameter of the back optic zone of the lens and the enlarged mesopic pupil. Any light source or well illuminated object is likely to have a halo around it. The difference in refractive power between the optic portion and the periphery of the lens will influence the intensity of the halo. In cases of excessive post-blink movement, distracting streaks of light emanate from light sources, which may alternate orientation as the lens lifts and drops. Such visual disturbances can be minimised by selecting a lens of large total diameter as this tends to be associated with a large back optic zone.

Gaining in popularity due to their comfort and good night vision among patients are semi-scleral RGP lenses, with a total diameter in the region of 14mm and a back optic zone diameter around 7.8mm.[17]

Presbyopic contact lenses

Correcting both distance and near vision is useful although not essential when driving; the alphanumeric detail on the dashboard is of high contrast, often illuminated and well above threshold. However, when undertaking near vision tasks such as reading the speedometer, the wearing of single-vision distance spectacles has been shown to result in more eye movements with longer fixations and more errors than multifocal or monovision contact lenses (Figure 3).[18]

Older drivers exhibit the highest crash rate per mile travelled and although impaired vision undoubtedly plays a role, it is only one of a number of factors. Considering vision alone, increasing age results in a reduction in contrast sensitivity associated with increased light scatter (primarily from the crystalline lens), reduced light transmission (lens transparency and smaller pupil) and cell loss in the retina and visual cortex. Presbyopes are therefore less likely to tolerate any further reduction in contrast sensitivity that might be caused by contact lenses.

Monovision

This is a simple and cheap option where the dominant eye is corrected for distance and the non-dominant for near. Accurate and full correction of the distance eye is critical and small degrees of astigmatism must be corrected.[19] A clear view of the dashboard may only be possible if the near vision lens is purposely under-plussed to give a longer working distance.

Monovision has been shown to impair stereopsis, although the importance of binocular vision for driving performance is not fully understood. Monovision is reasonably well tolerated (60-70 per cent of patients)[20], but up to 80 per cent report difficulty with night driving and glare in particular.[21] The near vision eye is under-minussed for distance and produces a blurred image of glare sources. The myopic halos are superimposed on the clear image and suppression of the blur is much more difficult at night due to the high luminance of the glare sources and low contrast of the remainder of the visual scene.[22] The greater the power disparity between the two lenses (ie the higher the add), the larger the halo.

Chu and colleagues[18] examined the effect of monovision on night driving performance using a closed-road circuit. Back in 2002, the same research team found that monovision had no implications for day-time driving performance,[23] but Chu *et al* showed that the distance at which street signs could be read at night was reduced by one-sixth compared to single-vision spectacle lenses. This has significant implications for braking times and stopping distances. The conclusions of the Chu study are limited by the lack of glare sources and the fact that they did not consider wearers who were adapted to monovision.

If symptomatic monovision patients are willing to wear spectacles for night driving, they can be easily managed by prescribing spectacles to wear over their contact lenses, to balance out their refraction for driving. Looking over one's shoulder to reverse on the near vision side will always be a problem.

Multifocal contact lenses

True multifocal designs allow the dashboard to be seen clearly, since they correct for distance, intermediate and near vision. This is not the case for true bifocal lenses (distance and near only), but there are very few of these available on the market now. Multifocal designs are constantly improving and most brands offer a range of adds with power profiles to complement the natural constriction of the pupil with age.

However, the very nature of a multifocal lens that is able to focus light rays from multiple distances, can lead to problems when driving at night. Simultaneous vision requires adaptation: being able to select the image of interest and ignore images at different distances that are also clear. The majority of patients can adapt to simultaneous vision during the day but it is not quite so easy under low illumination. The superimposed images tend to reduce the contrast of the image of interest and some patients report ghosting around lights at night, particularly individuals with large pupils.

A Spanish team has managed to quantify this luminous distortion using a test known as Starlights 1, which assesses the area of a test screen masked by glare from a central source. The amount of distortion was found to vary with optical design.[24]

Chu and colleagues[18] considered the implications of multifocal contact lenses in addition to monofocal lenses and spectacles. Centre-near multifocal lenses reduced the distance at which road signs could be read by one third compared to spectacles; a more significant reduction than for monovision. Unadapted participants wearing multifocal contact lenses were found to look at objects of interest for longer than spectacle wearers, perhaps because they struggled to see the detail. No difference in road sign or hazard recognition was found. They appeared to compensate for slightly poorer vision by driving more slowly than spectacle wearers. Despite this finding, when another study asked participants to subjectively rate monovision and multifocal lenses for a range of real life tasks, multifocal lenses were preferred, even for night driving.[25]

In conclusion, all types of presbyopic contact lens correction can affect night vision and potentially driving performance. Symptomatic monovision patients can be helped by providing over-spectacles for night driving. Multifocal wearers should be made aware that their night vision may be impaired. It goes without saying that no patient should drive until fully adapted to a new presbyopic contact lens correction.

Driving safety requires objects of interest to be identified quickly, processed and reacted to in an appropriate manner. Poor visual acuity and contrast sensitivity tend to make drivers more hesitant and slower, with poorer sign recognition and hazard avoidance. The fact that contact lenses can, under some circumstances, reduce contrast sensitivity, points to the need for a more thorough examination of drivers' vision than the crude number plate test used at present. ●

MULTIPLE-CHOICE QUESTIONS – take part at opticianonline.net

1 What is the estimated percentage of drivers that wear contact lenses for driving?
A 1-2 per cent
B 5-7 per cent
C 15-20 per cent
D 40-45 per cent

2 Which of the following statements about dry eyes and driving is FALSE?
A In-car ventilation reduces humidity levels
B Dry eye may reduce the ability to see road signs
C Drivers reduce their blink rate
D Dry eye is most problematic when driving in the morning

3 Which of the following statements about toric lens wear for drivers is TRUE?
A The irregular thickness significantly increases problems of dry eye
B The lens will not fully correct astigmatism
C Rotation from axis of cylinder is maximal when looking at the rear-view mirror and dashboard
D Toric lens orientation is not related to tear film quality

4 Which of the following best represents the light levels of roads in the UK?
A Scotopic
B Low mesopic
C High mesopic
D Photopic

5 Which of the following results in increased impact of higher order aberrations at night?
A Reduced tear film
B Increased pupil diameter
C Increased light scatter
D Fatigue

6 What percentage of monovision patients have reported problems with night driving and glare?
A 10 per cent
B 40 per cent
C 60 per cent
D 80 per cent

Successful participation in this module counts as one credit towards the GOC CET scheme administered by Vantage and one towards the Association of Optometrists Ireland's scheme.
The deadline for responses is November 3 2011

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