Novel use of a Franklin split lens for cycling with hemianopia

Michael D. Crossland, PhD MCOptom[1,2]

Mitchel Reuben, FBDO SMC (Tech)[1]

Sarah L. Bedford, DipHEd FDA[3]

[1]Moorfields Eye Hospital NHS Foundation Trust

[2]UCL Institute of Ophthalmology

[3]Patient and medical illustrator

Corresponding author: MD Crossland, Department of Optometry, Moorfields Eye Hospital, 162 City Road, London EC1V 2PD, UK; mcrossland@nhs.net

Keywords: Hemianopia; prism; visual field; bifocal

Running head: A Franklin split for hemianopia.

Word count: 2174

Submitted as short communication.

Updated draft 3 – with ‘key points’ this time!

The authors report no conflicts of interest and have no proprietary interest in any of the materials mentioned in this article.

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Abstract

Purpose: Optical rehabilitation for hemianopia includes the prescription of partial aperture prismatic lenses. Fresnel lenses for this purpose have poor optical quality, whilst bonded lenses have poor cosmesis and can only be made in glass, creating a potential hazard. Here we present an alternative lens type, which does not reduce contrast sensitivity and which can be made in plastic materials.

Methods: A rotated Franklin split lens was prescribed for the right eye only to provide a full aperture prismatic lens without using a Fresnel prism or bonded lenses. Using different refractive indices in each lens provided a minimal transition in thickness and an acceptable cosmetic appearance. This lens was prescribed to a 34-year old woman with homonymous right hemianopia. Her contemporaneous comments are presented.

Results: The rotated Franklin split lens provided 18D of prism over the temporal edge of the lens. The wearer noticed chromatic aberration with this lens, but was able to cycle comfortably when wearing the lens without any reduction in contrast.

Conclusions: A rotated Franklin split lens can be used for the optical rehabilitation of hemianopia. In this case study, cycling was possible with this lens.

Key Points

- **Fresnel prisms have been used for many years to increase the visual field of people with hemianopia, but these lenses reduce contrast sensitivity and the visibility of the scene.**

- **We have shown that a rotated Franklin split bifocal lens expands the visual field in hemianopia, by incorporating base out prism over the temporal portion of the lens.**

- **In this short communication we have presented qualitative statements from a patient using a rotated Franklin lens, along with a picture illustrating her perception through the lens.**

Background

Homonymous field loss is common, affecting almost 1% of all adults over 50 years of age.[1] Optical aids can benefit people with this type of field loss, particularly in those with hemianopia.[2,3]

Sector prisms, also known as sectorial or partial-aperture prisms, are used to increase the awareness of objects which would otherwise fall into the blind hemifield. Most commonly these are made using a base out Fresnel prism, applied to the temporal side of the spectacle lens corresponding to the nonseeing field (for example, base out to the temporal half of the right spectacle lens for a right hemianopia). Fresnel lenses reduce contrast sensitivity, attract dust, and are obvious to other people. An alternative is to use a bonded prism lens over the temporal half of a conventional spectacle lens. This offers better cosmesis and contrast sensitivity, but can only be made using glass lenses, which are heavy, have low impact resistance, and can cause severe ocular injury.[4]

In the United Kingdom, people with hemianopia are not usually allowed to drive a motor vehicle.[5] There is no legal minimum standard of vision for cycling, although a bike rider could be at risk of prosecution for ‘reckless cycling’ if they caused an injury through their own negligence when cycling. Cyclists who are visually impaired are more likely to report crashes where they collide with a kerb, bollard, or tram rail, but are not more likely to have crashes related to skidding, potholes, loss of control, or bicycle defects.[6] However, in the largest study to date of on-road bicycling by people with reduced vision, visual field loss was not related to slower cycling, more dangerous behaviour, or altered lane position, and the authors concluded that ‘there is no need to introduce legislative restrictions limiting the regular bicycle or pedelec use of visually impaired people’.[7]

A Franklin split lens is a type of bifocal where each part of the lens is made from an individual spectacle lens. Each lens is bisected and the semicircular lenses are bonded together along the flat edge. They are glazed into spectacles so that the joining line is horizontal in the primary position. Here we present the use of a rotated Franklin split lens – with a vertical dividing line - for the rehabilitation of a young adult with hemianopia (author SLB), alongside her qualitative reports of using this lens for cycling.

Methods

SLB was a 34 year old woman who was diagnosed with a small, 3mm, pituitary microadenoma after noticing visual disturbance in her right visual field. Her neurologist did not think the adenoma was responsible for her visual field loss, and noted her history of ocular and hemiplegic migraine, non-epileptic childhood seizures, and concussion.

Automated (Humphrey) perimetry had shown a homonymous, right-sided hemianopia not extending beyond the vertical midline (figure 1). The field results were reliable with no fixation errors in either eye. There were no fixation losses, 1/100 false positive errors and no false negative errors in the right eye; and no fixation losses, false positive errors or false negative errors in the left eye. This field defect was confirmed on manual Goldmann perimetry.

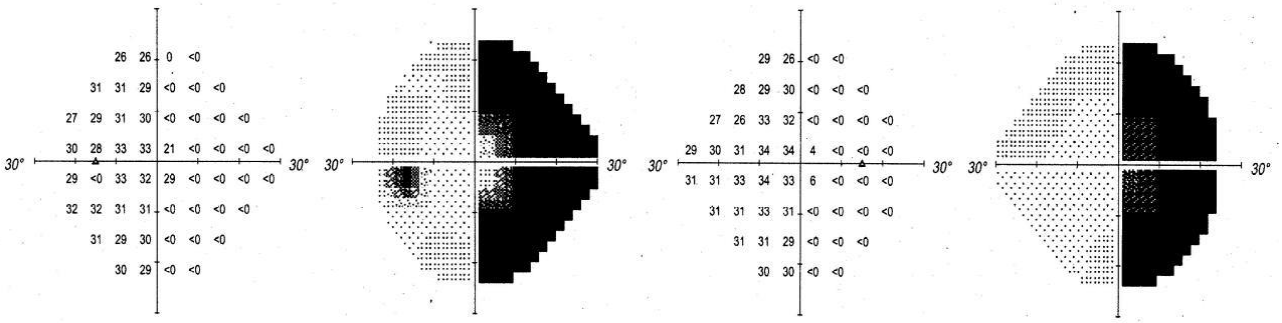

Figure 1. Full threshold static visual field plots for SLB.

In the low vision clinic, SLB confirmed that her primary rehabilitative goal was to cycle safely. She had not fallen, but had other mobility concerns including walking in to holly bushes on her right hand side. She reported some neck pain when working on her laptop, which she attributed to her compensatory head turn to the right. She was still able to work as a part-time medical illustrator and confirmed that she did not drive a car. She had received rehabilitation including visual exploration training using the Durham Reading and Exploration training and the Read-right online programme.[8] She used a dome (Visolett) magnifier for small print and a pair of single vision reading glasses for illustration work.

On examination her visual acuity (with small myopic correction) was R. 0.0 logMAR (6/6), L. -0.1 logMAR (6/5). With both eyes open she could see -0.16 logMAR (6/4-2) and 0.32M (-0.1 logMAR, N2) size print at 40cm. Confrontation visual fields confirmed the presence of a right hemianopia.

She was right eye dominant and right-handed.

Yoked prisms (12Δ base out right eye; 12Δ base in left eye) were demonstrated to address SLB's neck pain when looking at her laptop. She appreciated the image movement with these lenses but did not think they would help.

She disliked peripheral (Peli) prisms, which were demonstrated by fitting them to the right lens of her own single-vision spectacles, saying they made her 'disoriented.'

However, she found benefit from a sector prism of 20Δ base out fitted over the temporal edge of her right spectacle lens.

Fresnel based lens

A 20Δ Fresnel prism (3M, Maplewood, Minnesota, USA) was fixed to the back surface of temporal half of the right lens of SLB's single vision distance photochromic spectacles, with the prism boundary sitting 10mm to the temporal side of her pupil centre.

Incorporated lens

After not tolerating the Fresnel lens, a Franklin split lens was ordered for the right eye, glazed at 90º to conventional format, such that the division between the two lenses was vertical and bisected the pupil centre in primary gaze (figure 2).

Figure 2. The Franklin split spectacles.

The lens ordered was: R. -2.25/-1.50x120; add +0.00, 18Δ prism base down, which when rotated 90 degrees and glazed into the frame gave a prescription of R. -2.25/-1.50x30 with an 18Δ base out prism over the temporal half of the lens. To minimise the difference in lens thickness at the division between the two lenses, the lens with prism was ordered in 1.67 high index plastic (refractive index of 1.67), and the lens without prism in CR39 (refractive index 1.5).

The left lens was a single vision distance lens with no prism, to the prescription:
L. -2.00/-2.25x150.

In this paper we report SLB's contemporaneous email correspondence with MDC as she tried cycling with the Fresnel and Franklin lenses.

Results

Figure 3 shows suprathreshold Esterman binocular visual fields without and with the Franklin split lens, whilst looking in the primary position of gaze. The visual field tests were reliable and showed around 30º of binocular field expansion with the Franklin split lens.

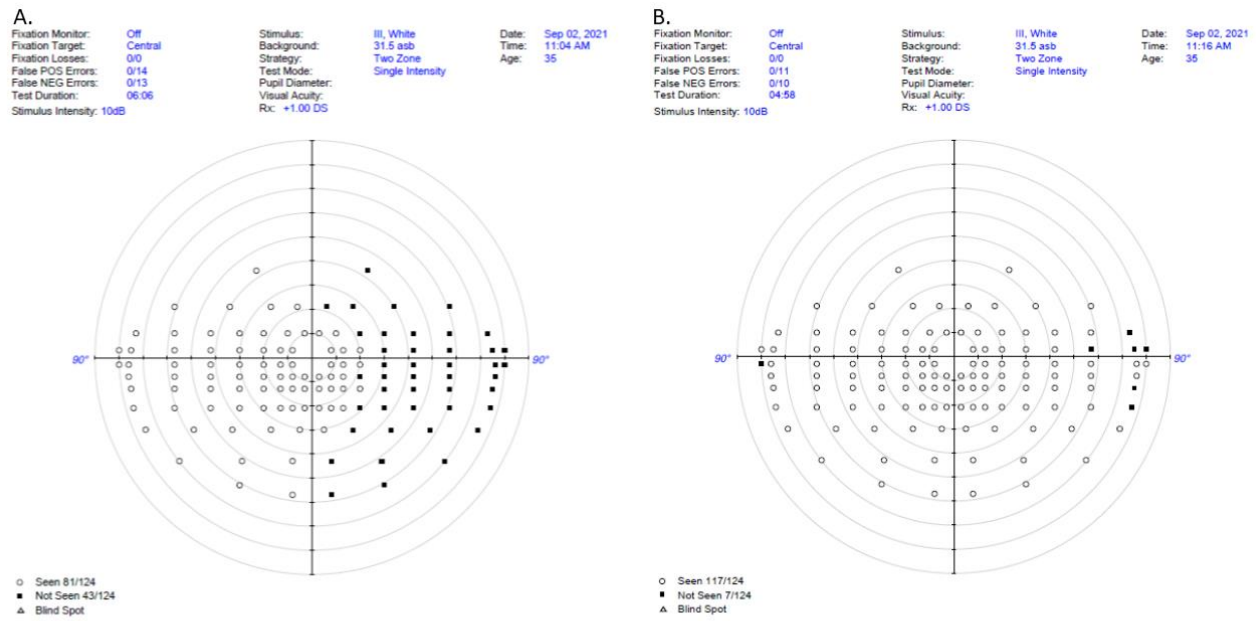

Figure 3. Suprathreshold Esterman binocular visual field plot without (left) and with (right) the Franklin split spectacles, whilst SLB looked straight towards the central fixation target.

SLB had mixed experiences with her Fresnel sector prism:

'Yesterday morning I had to be somewhere at 7am which meant cycling in the dark for the first time with these specs. I was quite apprehensive about it, and it was raining to boot. As it worked out I actually found seeing the cars much easier with the headlights and indicators in the dark. I am still having a bit of a struggle with contrast though and it was very difficult to see pedestrians/runners on the pavement and off road cycle track.'

These problems in low light and for low contrast objects were resolved when she received the Franklin lens, several weeks later:

'the level of contrast I was aware of was much better than through the Fresnel prism.'

After wearing the Franklin lens for one month, cycling was easier:

'In terms of cycling, and walking outside in general, I feel so much safer with them. Not only can I now cycle in the half light and still feel comfortably aware of surrounding traffic (which is a massive improvement on the Fresnel lenses), I am also getting much more adventurous in where I am cycling…I've now managed a few times to cycle up to the side of town nearer where my sister lives (roads I know the routes if someone was driving me there, but hadn't cycled before) doing round trips of about 15 miles and feeling safe doing it, which is great! Until I'd got these specs I was generally not going more than about 6 miles a trip because I didn't want to go out of my familiar zone.'

When walking or cycling, SLB reported looking 'very slightly' into the prism. When she became aware of an obstacle to her right, she turned her head more than she would without the prism, to observe the obstacle through the non-prismatic part of the spectacles.

With these glasses she found cycling more enjoyable:

'When I am cycling upstream with the brook on my right I am now often aware of the ducks, moorhens, and even the egret on it which is pleasant. I did get a bit of a shock one morning when the egret was flying right down the path towards me - it seems much bigger when it is in flight!'

She was aware of chromatic aberration towards the apex of the prism:

'One thing I am experiencing though that I didn't expect is rainbows. When I'm outside and the sun is high in the sky (generally just before 1pm) I get a vertical rainbow down my vision for a few minutes. I'm presuming this is something to do with the angles of the glass where the two parts of the lens meet, and it only seems to happen for a few minutes when I'm outside and the sun is really high.'

She did not find the prism scotoma difficult:

'[Author MR] talked about there being a bit of a scotoma where the two parts of the lenses meet – I am aware of this when I look at a specific angle, but most of the time how I look through them as they naturally sit on my face I experience more of a "ghost image" (...what is on my right is sort of superimposed on part of what is straight ahead of me).'

As a 'ghost image' could refer to diplopia or visual confusion, SLB clarified this by creating an image simulating her perception with both eyes open (figure 4) showing diplopia and visual confusion.

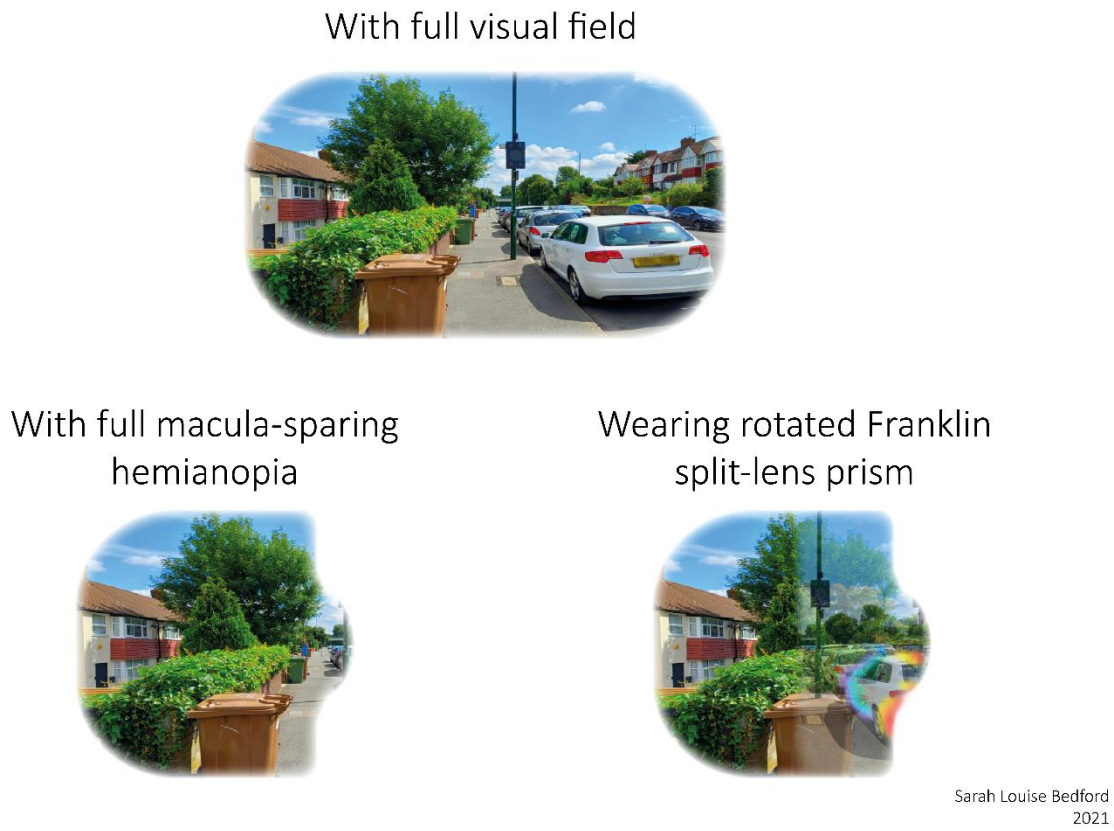

Figure 4. SLB's simulation of her perception through the spectacles.

SLB was concerned about the appearance of the spectacles:

'One other thing to note is that I'm getting an awful lot of questions about how I 'broke my glasses'...when every doctor, nurse and [health care assistant] asked me the same thing I got a bit irritated.'

The position of the prism in the Fresnel and Franklin lens was chosen by SLB when the spectacles were dispensed and differed between the two spectacles. After trialling the Fresnel lens, she selected a more central position for the split in the Franklin lens, perhaps as she became comfortable with more of the lens having a prism incorporated, as suggested by Hoppe and Perlin.[3] The prism power also differed: 18Δ was the most which could be incorporated in the frame selected by SLB. It may have been possible to incorporate more prism in a smaller frame but this would have limited the field of view. Balancing the closest possible vertex distance, the maximum possible field of view and the maximum possible amount of prism was challenging.

Conclusions

We believe that this is the first report of using a rotated Franklin split lens for the rehabilitation of hemianopia. The spectacles were useful for cycling, with no reported reduction in contrast sensitivity. Advantages of using this lens rather than a conventional partial aperture bonded glass sector prism include lighter weight, better cosmesis, and better safety.

Looking through a unilateral prism can lead to confusion, suppression or diplopia. Eye dominance and binocular status should be considered when deciding on whether to fit a prism monocularly or binocularly.[9] SLB did experience diplopia and confusion through the prism, along with chromatic aberration, but not suppression (figure 4).

Limited data are available on the safety of cycling with visual impairment, and the reports which do exist tend to come from the Netherlands, a country with excellent cycle infrastructure. SLB was an experienced cyclist before her field loss was identified, and she was careful to cycle only on off-road settings with her spectacles before attempting to ride on the road. Experience of cycling before the onset of visual impairment has been identified as an important predictor of cycling safety.[10] There are no publications on cycling using prism-based field expansion, although there are anecdotal reports of cyclists using peripheral prisms (personal communication, Dr Alex Bowers, Schepens Eye Research Institute, 14 June 2021).

The only lens options available for partial-aperture prisms are glass bonded lenses, Fresnel prisms, or this rotated Franklin lens. Future advances in glazing technology may lead to sector prisms being made from a single plastic lenses, using computer numeric control (CNC) technology.

This case report is limited to describing one motivated young adult with hemianopia, and her success with this lens may not be replicated in other people with homonymous field loss. In particular, her long cycling history may have made her more likely to be able to ride a bicycle safely with this lens. Her professional background as a medical illustrator gave her a clear understanding of her visual field loss and the purpose of the spectacle lens and enabled her to create a useful simulation of her experience (figure 4).

Franklin split lenses are rumoured to have been developed by Benjamin Franklin in the late 18th century. More than 200 years later, we believe this is the first time they have been used in the management of visual field loss.

Acknowledgements

The authors wish to thank Jack Carter at Optimum Lens Coatings for providing the lens, and Mary Bairstow at Birmingham University Hospitals for referring SLB to us.

References

1. Singh Gilhotra, J., Mitchell, P., Healey, P. R., Cumming, R. G. & Currie, J. Homonymous visual field defects and stroke in an older population. *Stroke* **33**, 2417–2420 (2002).
2. Bowers, A. R., Keeney, K. & Peli, E. Randomized crossover clinical trial of real and sham peripheral prism glasses for hemianopia. *JAMA Ophthalmol.* **132**, 214–222 (2014).
3. Hoppe, E. & Perlin, R. R. The effectivity of Fresnel prisms for visual field enhancement. *J. Am. Optom. Assoc.* **64**, 46–53 (1993).
4. Hoskin, A. K., Philip, S., Dain, S. J. & Mackey, D. A. Spectacle-related eye injuries, spectacle-impact performance and eye protection. *Clinical and Experimental Optometry* vol. 98 203–209 (2015).
5. Driver & Vehicle Licensing Agency. *Assessing fitness to drive - a guide for medical professionals*. (DVLA, 2021).
6. Schepers, P. & den Brinker, B. What do cyclists need to see to avoid single-bicycle crashes? *Ergonomics* **54**, 315–327 (2011).
7. Jelijs, B., Heutink, J., de Waard, D., Brookhuis, K. A. & Melis-Dankers, B. J. M. How visually impaired cyclists ride regular and pedal electric bicycles. *Transp. Res. Part F Traffic Psychol. Behav.* **69**, 251–264 (2020).
8. Ong, Y. H. *et al.* Read-Right: A 'web app' that improves reading speeds in patients with hemianopia. *J. Neurol.* **259**, 2611–2615 (2012).
9. Apfelbaum, H. L., Ross, N. C., Bowers, A. R. & Peli, E. Considering Apical Scotomas, Confusion, and Diplopia When Prescribing Prisms for Homonymous Hemianopia. *Transl. Vis. Sci. Technol.* **2**, 2 (2013).
10. Jelijs, B., Heutink, J., de Waard, D., Brookhuis, K. A. & Melis-Dankers, B. J. M. Key factors for the bicycle use of visually impaired people: a Delphi study. *Disabil. Rehabil.* **41**, 2758–2765 (2019).