What effect does laser photocoagulation have on driving visual fields in diabetics?

A.R. PEARSON, V. TANNER,
S.J. KEIGHTLEY, A.G. CASSWELL

Abstract

Although laser panretinal photocoagulation (PRP) for proliferative diabetic retinopathy is known to cause peripheral field constriction, the risks of failing the UK driving field test following treatment are currently unclear as the small number of previous studies have conflicting results. Following PRP using only argon laser with a 500 μm spot size, both uniocular and binocular Esterman visual fields from 60 diabetic patients were assessed by the Chairman of the Visual Standards Sub-Committee of the Royal College of Ophthalmologists. Forty-two per cent of uniocular fields from treated eyes failed. Twelve per cent of binocular fields from those having bilateral PRP failed. Type II diabetes was associated with a significant increase in the risk of failure. Although there is a high risk of failure in any given treated eye, 88% of diabetics will pass a binocular field test, even if both eyes are treated.

Key words Diabetes, Driving, Panretinal photocoagulation, Retinopathy, Visual fields

Laser panretinal photocoagulation (PRP) is a widely used treatment for proliferative diabetic retinopathy. Several studies¹⁻⁵ have demonstrated that it is effective in causing regression of new vessels and reducing the risk of sight-threatening complications.

At the same time, however, laser photocoagulation of peripheral retina causes a loss of visual field.^{3,4,6-8} Although the effect of loss of field on driving safety is debated,⁹⁻¹¹ adequate visual field is necessary to hold a UK driving licence.¹² Current Driver and Vehicle Licensing Agency (DVLA) regulations use the Royal College of Ophthalmologists 'Definition for the Minimum Field for Safe Driving for Group 1 Ordinary Drivers', which states that 'the minimum visual field for safe driving is at least 120° on the horizontal. In addition, there should be no significant field defect which encroaches within 20° of fixation either above or below the horizontal meridian'.¹³

The risk of failing the UK driving field test following laser PRP is currently unclear. Estimates from the small number of studies available range from 9.0% to 87.5%.¹⁴⁻¹⁷ Such a wide variation probably reflects the problems present in these studies, which include small sample size, mixes in photocoagulation type and spot size, incorrect field testing techniques and unspecified assessment criteria.

Using standardised treatment technique and field assessment, our study aimed to: (1) establish the risk of failing the UK driving field test after both unilateral or bilateral laser PRP and (2) identify risk factors that predispose to failure.

Patients and methods

Patients eligible for inclusion in the study were diabetics receiving laser PRP for proliferative retinopathy whose visual acuity following treatment was at least 6/12 in the treated eye (or in the better eye if the patient received bilateral treatment), patients being selected by case note review. This level was chosen as a suitable approximation to that required by the DVLA for holding a Group 1 driving licence, which states that 'a driver must be able to read a vehicle registration plate at 20.5 m in good daylight'.¹² This has been shown to equate to a binocular Snellen acuity of approximately 6/10.¹⁸

Patients received a fully documented amount of treatment using only argon laser PRP. Treatment was according to Diabetic Retinopathy Study (DRS) guidelines. The laser spot size used was 500 μm . Patients were included with both unilateral and bilateral treatment, with or without additional focal laser. Eyes with coexistent disease known to cause visual field loss were excluded.

Visual field assessment was carried out using the Esterman programme of the Humphrey visual field analyser. Each patient had uniocular field tests for each eye independently as well as a binocular field. All visual fields were examined by the Chairman of the Visual Standards Sub-Committee of the Royal College of Ophthalmologists, in a randomised and masked manner, using the

A.R. Pearson
A.G. Casswell ✉
Sussex Eye Hospital
Eastern Road
Brighton BN2 5BF, UK

V. Tanner
Oxford Eye Hospital
Oxford, UK

S.J. Keightley
North Hampshire Hospital
Basingstoke, UK

1994 Royal College of Ophthalmologists definition for the minimum field for safe driving. Any field test considered to be unreliable, for example due to a high number of fixation losses or false positive or negative errors, was repeated.

Results

The entry criteria were met by 60 patients. The mean age of the patients was 52.5 years; 57% were male, 43% female. In 59% of patients diabetes was type I (categorised as patients younger at onset, rarely obese, requiring insulin for deficiency believed due to autoimmune disease); in the remaining 41% it was type II (categorised as patients older at onset, often overweight, not necessarily requiring insulin for deficiency and resistance believed to be of non-autoimmune origin). The mean duration of diabetes was 22.5 years. Peripheral new vessels was the initial indication for PRP in 61% of patients, disc new vessels in the remaining 39%. At the time of field testing, which was a minimum of 1 month after the last laser treatment, retinopathy was considered stable in 88% of eyes, and these eyes had received a mean of 2810 burns. Additional focal laser treatment had been given to 30% of eyes. Details of the main features of the group are shown in Table 1.

Failure rates following PRP

Unioocular fields were examined from 86 treated eyes. Of these, 36 (42%) failed. Of 17 unioocular fields of eyes that had received no PRP, 2 (12%) failed. Of the 21 binocular fields in which only one eye had been treated, 1 (5%) failed. Of the 34 binocular fields from patients who had received bilateral treatment, 4 (12%) failed, these patients receiving a mean of 2987 burns per eye. Four of 8 (50%) patients who failed both unioocular field tests passed the binocular test. The minimum visual acuity in the second eye of the patients having a binocular field test was 6/60. The results are summarised in Table 2.

Examples of fields assessed are shown in Figs. 1 and 2.

Table 1. Summary of patient characteristics

Age (years)	Mean: 52.5 Range: 20–71
Sex	Male: 57% Female: 43%
Type of diabetes	Type I: 59% Type II: 41%
Duration of diabetes (years)	Mean: 22.5 Range: 4–47
Initial indication for PRP (% eyes)	Disc new vessels: 39% Peripheral new vessels: 61%
No. of PRP burns (per eye)	Mean: 2810 Range: 378–11 580
Focal laser (% eyes)	Focal: 30% No focal: 70%

Risk factors for failing

To avoid bias due to correlation between the two eyes of the same patient,¹⁹ for analysis of the unioocular fields one eye from those patients in whom both eyes had been treated was randomly selected, providing 60 unioocular fields for analysis. Of these, 36 were from type I diabetics, of which 12 failed (1/3), compared with 16 of the 24 (2/3) from type II diabetes. Type II diabetes was therefore associated with a significant increase in the risk of failing a unioocular field test ($\chi^2 = 5.16, p = 0.02$). Of the 34 binocular fields, 19 were from type I and 15 from type II diabetics. Three of the 4 failures were in type II diabetics. These numbers are too small for χ^2 analysis.

Similar χ^2 testing was used for the unioocular fields to analyse the risks from location of new vessels, sex of the patient, and whether the patient had received additional focal laser. No significant increase in risk was found for these variables.

For both unioocular and binocular fields Students *t*-test was used to analyse the impact of age, duration of diabetes, and the number of burns applied. For both types of field, patients failing were more likely to be older (unioocular $p = 0.0027$, binocular $p = 0.0086$). However, there was no significant difference in age between those who passed and those who failed within either the type I or type II diabetic groups ($p = 0.51$ and $p = 0.67$ respectively). For unioocular, but not binocular fields, there was a significant difference in the duration of diabetes. No significant increase in risk was found in relation to the number of burns applied. Table 3 summarises the results.

Discussion

It is important that ophthalmologists are able to advise patients on whether laser treatment for proliferative retinopathy may itself jeopardise their licence to drive. Unfortunately, previous studies have produced contradictory results, with reported failure rates ranging from 9.0% to 87.5% in binocular field tests for those patients having bilateral laser PRP. Such a wide variation probably reflects several factors. For example:

- 1. In two of the studies an overlay combination of the two unioocular fields was used as a measure of the binocular field. This is unsatisfactory as it fails to recognise the phenomenon of binocular enhancement that has been estimated to improve field sensitivity by about 20%.²⁰

Table 2. Summary of failure rates

Field test	Failure rate
<i>Unioocular fields</i>	
Untreated eyes	2/17 (12%)
Treated eyes	6/86 (42%)
<i>Binocular fields</i>	
One eye treated	1/21 (5%)
Both eyes treated	4/34 (12%)

(a)

(b)

(c)

Fig. 1. Left (a), right (b) and binocular (c) fields from the same patient. Although the patient fails with each eye individually due to severe bilateral peripheral field constriction, he passes when assessed binocularly.

2. In the assessment of the visual fields a degree of interpretation of the minimum field definition is possible – for example, in deciding whether the horizontal or vertical field is adequate or what constitutes a significant scotoma. In only one of the four studies was, for example, the Chairman of the Visual Standards Sub-Committee involved in analysing the fields. Such differences in interpretation may account for some of the variation in the pass/fail rates.
3. The sample size of three of the four studies was small, with 25 patients or fewer.
4. The type of laser used (e.g. argon, diode, or a combination) or laser spot size employed (ranging from 200 to 500 μm) may also have some, as yet unquantified, influence on the outcome.

None of the previous studies has documented a failure rate in a given treated eye. The high figure in our study of 42% indicates that a significant proportion of those receiving bilateral treatment are able to pass binocularly only because defects in the visual field of one

eye are compensated by adequate corresponding field in the fellow eye. Two factors may help to account for this high failure rate.

Fig. 2. Example of severe peripheral field loss producing a failure of the field test even when assessed binocularly.

Table 3. Summary of results of risk factor analysis

	Unocular fields			Binocular fields		
	Pass	Fail	Significance	Pass	Fail	Significance
Mean age (years)	49.1	56.5	$p = 0.0027$	47.5	66.5	$p = 0.0086$
Mean duration of diabetes (years)	25.7	19.3	$p = 0.041$	19.8	22.3	$p = 0.70$
Mean no. of burns	2602	2639	$p = 0.47$	5780	7060	$p = 0.26$
Sex	Male: 19 Female: 13	Male: 15 Female: 13	$p > 0.50$	Male: 18 Female: 12	Male: 2 Female: 2	
Type of diabetes	Type I: 24 Type II: 8	Type I: 12 Type II: 16	$p = 0.02$	Type I: 18 Type II: 12	Type I: 1 Type II: 3	
Site of new vessels at initial treatment	Disc: 10 Peripheral: 22	Disc: 10 Peripheral: 18	$p > 0.50$			
Additional focal treatment	Focal: 7 No focal: 25	Focal: 11 No focal: 17	$p > 0.10$	Focal: 13 No focal: 17	Focal: 1 No focal: 3	

First, it is established that diabetics may have field defects prior to any PRP.^{21–27} For example, Trick *et al.*²³ have shown that in a group of 57 diabetics with retinopathy ranging from none to mild background as many as 26% of Humphrey 30–2 fields were considered abnormal when compared with controls. Using identical field testing, Henricsson and Heijl²⁶ found visual field loss in 44% of fields from 63 patients with moderate to severe non-proliferative diabetic retinopathy. In our study, 2 of 17 untreated eyes had sufficient field loss to cause failure; both were in long-standing type I diabetics. In eyes requiring PRP one might expect visual field abnormalities before treatment to be even more marked.

Second, there may be some effect of the choice of spot size. Geometrically, it can be shown that the III4e (4 mm) target at 1/3 m on the Humphrey field analyser creates an image size on the retina of approximately 210 µm in an eye of normal length. A calibrated spot size of 500 µm in our patients was magnified approximately 5% by the Mainster lens used in the delivery.²⁸ Furthermore, there is probably an as yet unquantified increase in effective burn size due to lateral thermal spreading.²⁹ It is therefore quite possible for the complete target to lie within the area of a single burn. A previous report¹⁵ has suggested that failure rates may be higher in those treated with larger laser spot sizes, and recommends using a setting of 200 µm, yet such a conclusion is hard to justify as it is based on the results from only 16 patients and most of the patients who passed (8/14) had received burns greater than 200 µm in size. Even at a 200 µm setting the risk of complete occlusion of the target persists. Furthermore, the effectiveness of 200 µm PRP is not known. The percentage of retina treated is probably crucial to the effectiveness of PRP. The burn area of a 200 µm spot is less than one-sixth that of a 500 µm spot so that, whilst the chance of occlusion by any one burn may be lower, a far greater number of burns may be necessary to achieve regression of the new vessels.

Age and type of diabetes emerged as significant risk factors for failing the field test. The two are related in that type II diabetics are an older age group than type I diabetics. It is known that visual field defects are more common with increasing age.¹⁰ However, in this study, the ages of those who passed and those who failed were similar within the type I and type II diabetic groups,

suggesting that it is the type of diabetes that affects the risk of failure and not age *per se*. The reason for this may relate to the presence of more severe pre-treatment field loss in the type II diabetics compared with those with type I diabetes. This has been seen in some^{23,25} but not all²⁶ of the studies examining the visual fields, prior to any laser treatment, of diabetic patients with various levels of diabetic retinopathy. Although the reasons for this are unclear, if macular function and hence visual acuity were affected in a similar way to peripheral visual fields it might also provide some explanation for the low proportion of patients with type II diabetes in this study in relation to its high relative population prevalence compared with type I diabetes, as many of the type II diabetics may have been excluded by virtue of inadequate visual acuity.

Duration of diabetes was significantly shorter in those failing the field tests compared with those passing. This is contrary to what one might expect, though it could indicate the presence of aggressive disease in those failing or possibly delayed diagnosis in the type II diabetics, who make up most of the group who failed. However, a significant difference was seen only for the unocular fields, so the relevance of the finding is not clear.

By controlling for type of PRP, spot size and both the measurement and assessment of visual fields it is hoped that a more accurate estimate of the risk of failing the UK driving standard may now be given to diabetics receiving PRP. Those with sight in only one eye at the time of treatment, or who lose the sight in their other eye at a later date, have a high risk of failing a driving field test. For the majority, however, who have vision in both eyes, the risks are much lower. Of these patients 88% will pass the field test, even if both eyes are treated.

References

1. The Diabetic Retinopathy Research Group. Preliminary report on effects of photocoagulation therapy. *Am J Ophthalmol* 1976;81:383–96.

2. Hercules BL, Gayed II, Lucas SB, Jeacock J. Peripheral retinal ablation in the treatment of proliferative diabetic retinopathy: a 3 year interim report of a randomised, controlled study using argon laser. *Br J Ophthalmol* 1977;61:555.

3. The Diabetic Retinopathy Study Research Group. Photocoagulation treatment of proliferative diabetic retinopathy: the second report of Diabetic Retinopathy Study findings. *Ophthalmology* 1978;85:82–106.
4. The Diabetic Retinopathy Study Research Group. Photocoagulation treatment of proliferative diabetic retinopathy: clinical application of Diabetic Retinopathy Study (DRS) findings. DRS report no. 8. *Ophthalmology* 1981;88:583–600.
5. Hamilton AM, Townsend C, Khoury D, Gould E, Blach RK. Xenon arc and argon laser photocoagulation in the treatment of diabetic disc neovascularisation. I. Effect on disc new vessels, visual fields, and visual acuity. *Trans Ophthalmol Soc UK* 1981;101:87–92.
6. Frank RN. Visual fields and electro-retinography following extensive photocoagulation. *Arch Ophthalmol* 1975;93:591–8.
7. Seiberth V, Alexandridis E, Feng W. Function of the diabetic retina after panretinal argon laser photocoagulation. *Graefes Arch Clin Exp Ophthalmol* 1987;225:385–90.
8. Early Treatment Diabetic Retinopathy Study Research Group. Early photocoagulation for diabetic retinopathy. ETDRS report no. 9. *Ophthalmology* 1991;98:766–85.
9. Council FM, Allen TA. A study of the visual fields of North Carolina drivers and their relationship to accidents. Highway Safety Research Centre, University of North Carolina, North Carolina, 1974.
10. Johnson PA, Keltner JL. Incidence of visual field loss in 20 000 eyes and its relationship to driving performance. *Arch Ophthalmol* 1983;101:371–5.
11. Buyk A, Missotten L, Maes MJ, Van de Vorrde H. Assessment of the driving behaviour of visually handicapped persons. In: *Vision in vehicles*, vol 2. Amsterdam: North-Holland, 1988: 131–42.
12. Drivers Medical Group. At a glance guide to the current medical standards of fitness to drive. Bristol: DVLA, March 1996.
13. Definition of the minimum field of vision for safe driving. Royal College of Ophthalmology Guidelines, 1994.
14. Williamson TH, George N, Flanagan DW, Norris V, Blamires T. Driving standards visual fields in diabetic patients after panretinal laser photocoagulation. In: *Vision in vehicles*, vol 3. Amsterdam: North Holland, 1991:265–72.
15. Hulbert MFG, Vernon SA. Passing the DVLC field regulations following bilateral pan-retinal photocoagulation in diabetics. *Eye* 1992;6:456–60.
16. Buckley SA, Jenkins L, Benjamin L. Fields, DVLC and panretinal photocoagulation. *Eye* 1992;6:623–5.
17. Mackie SW, Webb LA, Hutchison BM, Hammer HM, Barrie T, Walsh G. How much blame can be placed on laser photocoagulation for failure to attain driving standards? *Eye* 1995;9:517–25.
18. Drasdo N, Haggerty CM. A comparison of the British number plate and Snellen vision tests for car drivers. *Ophthalmol Physiol Opt* 1981;1:39–54.
19. Thompson JR. The χ^2 test for data collected on eyes. *Br J Ophthalmol* 1993;77:115–7.
20. Mills RP, Drance SM. Esterman disability rating in severe glaucoma. *Ophthalmology* 1986;93:371–8.
21. Taylor E, Dobree JH. Proliferative diabetic retinopathy: site and size of initial lesions. *Br J Ophthalmol* 1970;54:11–8.
22. Wisznia KI, Lieberman TW, Leopold IH. Visual fields in diabetic retinopathy. *Br J Ophthalmol* 1971;55:183–8.
23. Trick GL, Trick LR, Kilo C. Visual field defects in patients with insulin-dependent and non-insulin-dependent diabetes. *Ophthalmology* 1990;97:475–82.
24. Buckley S, Jenkins L, Benjamin L. Field loss after panretinal photocoagulation with diode and argon lasers. *Ophthalmology* 1992;82:317–22.
25. Chee CKL, Flanagan DW. Visual field loss with capillary non-perfusion in preproliferative and early proliferative diabetic retinopathy. *Br J Ophthalmol* 1993;77:726–30.
26. Henricsson M, Heijl A. Visual fields at different stages of diabetic retinopathy. *Acta Ophthalmol (Copenh)* 1994;72:560–9.
27. Henricsson M, Heijl A. The effect of panretinal laser photocoagulation on visual acuity, visual fields and on subjective visual impairment in preproliferative and early proliferative diabetic retinopathy. *Acta Ophthalmol (Copenh)* 1994;72:570–4.
28. Mainster MA, Crossman JL, Erickson PJ, Heacock GL. Retinal laser lenses: magnification, spot size, and field of view. *Br J Ophthalmol* 1990;74:177–9.
29. Schatz H, Madeira D, McDonald HR, Johnson RN. Progressive enlargement of laser scars following grid laser photocoagulation for diffuse diabetic macular oedema. *Arch Ophthalmol* 1991;109:1549–51.