UK exceptional cases driving application outcomes in post-stroke homonymous hemianopia: Results from a clinical study

Abstract

Purpose: We report results in relation to returning to driving in the UK under the exceptional cases rule for visual field loss.

Methods: the Hemianopia Adaptation Study (HAST) is a prospective clinical study recruiting adult stroke survivors with new onset homonymous hemianopia. The mobility assessment course (MAC) was used to measure navigational scanning. Car drivers were offered a 1-year post-stroke assessment to consider referral for driving assessment.

Results: Of 144 participants, 51 were eligible for driving assessment, with 13 (25.4%) accepting appointment for UK Driving and Vehicle Licensing Agency (DVLA) referral. A statistically significant difference in gender and baseline Barthel (stroke severity) scores was found between those requesting referral and those declining (p=0.046; p<0.001). MAC outcomes were significantly different, with those referred having a lower percentage of target omissions (9.0%) and faster mean course completion time (46.0 seconds), than those not referred (28.3% / 72.5 seconds) (p=0.006 / p<0.001). Twelve of the 13 referred were offered a driving assessment by the DVLA. All 12 passed and returned to driving.

Conclusions: It is possible for individuals with post-stroke homonymous hemianopia to return to driving, where exceptional cases criteria are met. There is evidence to support use of the MAC as a clinical measurement of adaptation.

Keywords: Hemianopia; Stroke; Driving; Adaptation; Exceptional cases; Mobility Assessment Course; Visual impairment

Background

Driving a car is considered a valuable benefit, providing individuals with autonomy and enjoyment [1, 2]. The importance a person places on driving depends on a number of personal factors including mobility, family / social circumstances, location in community, availability of public transport links, occupation and finances.

Homonymous hemianopia is a loss of visual field to one side which can occur after stroke. Point prevalence of new onset visual field loss following acute stroke has been reported at 28% [3]. Visual restrictions and licensing laws vary across countries, however, in most situations the presence of homonymous hemianopia is a barrier to driving [4-6]. Specifically, hemianopic defects can impair visuo-motor control, which can in turn lead to an adverse affect on hazard detection, steering stability and lane position [7].

Driving cessation has been related to increased levels of depression, a decrease in independence / employment opportunities and reduction in social interactions [8-10].

There are some countries (for example, UK, Belgium, Switzerland, Netherlands and Canada) where individuals with a stable visual field loss who meet specified criteria, may be eligible to take an on-road assessment for re-licensing [4, 11, 12]. In the UK, guidance set out for drivers to apply for this on-road assessment is called the exceptional cases rule [4]. This rule applies only to group one drivers, for the use of a car or motorcycle, whose driving entitlement has been removed due to a visual field defect.

In England, Scotland and Wales, driving regulations are set by the DVLA. In Northern Ireland the rules regarding medical fitness to drive are the same as the DVLA, however are governed by the Driver and Vehicle Agency (DVA). The DVLA sets medical standards with reference to group one (car / motorcycle) and group two (large lorries / buses) licence holders. In summary, group one drivers hold entitlement to drive category B vehicles which include a weight up to 3,500kg maximum authorised mass (MAM) with up to 8 passengers and a trailer up to 750kg. Whereas group two drivers are those who have category C and D on their licences. Category C is for large lorries over 3,500kg, with a trailer up to 750kg and category D includes entitlement to drive any bus with more than 8 passengers.

A person holding a group one licence is not permitted to drive for one month following a diagnosis of stroke. After this time, driving may resume if there has been a satisfactory clinical recovery [4]. It is the individuals responsibility to inform DVLA about any medical conditions that affect or may affect their ability to drive.

As well as these guidelines around stroke diagnosis, there are strict vision regulations that all group one drivers must meet [4]. These include standards for a minimum area of visual field. DVLA specify that car drivers must meet minimum standards including a horizontal visual field of at least 120°, with no significant defect in the central 20°.

For consideration of relicensing under the exceptional cases rule, group one drivers must meet strict criteria as set out by DVLA [4]. These include that the defect must have been present for at least twelve months, caused by an isolated event such as stroke and there must be clinical confirmation of full functional adaptation.

The DVLA requirement for a clinical confirmation been put forward as a way of assisting the DVLA in their decision to allow a practical driving assessment to take place [13].

There are limitations to the exceptional cases rule in that there is no clear definition of the term ‘full functional adaptation’. Professionals do not have any way of measuring or assessing if a person has adapted to their visual field loss and are required to make a personal judgement, which gives rise to inconsistencies and inequalities in experiences.

The process of application for the exception cases rule is often poorly understood by health care professionals, leading to inconsistencies in referral and information provided to patients.

A further limitation of the exceptional cases rule is a lack of evidence supporting the requirement for a driver to have had a visual field defect for at least twelve months before being considered for driving assessment. There is no allowance for individual adaptation processes to be considered or for a personalised approach to the rule in terms of timing.

The literature reports that the exceptional cases rule is often not pursued for a variety of reasons including lack of awareness of the legislation, lack of long-term follow-up of patients and a general reluctance among professionals to confirm functional adaptation [14]. There is a lack of guidance provided for professionals to support this confirmation of adaptation which contributes to this reluctance.

Once driving assessment has taken place, the DVLA make an outcome decision based on assessment reports and previous medical history. An individual can have their driving licence re-instated, refused or a third option for three months of driving tuition prior to a second re-assessment.

Returning to driving is an important rehabilitation goal for many individuals with homonymous hemianopia [15]. There has been an increasing number of studies in recent years on evaluating performance of hemianopic drivers in on-road and simulated driving [7, 16-19]. However, reviews of the literature have found that the level of visual field loss that is incompatible with safe driving remains unknown [7, 20].

In addition, some studies have reported a difference in outcomes for driving cessation observed between men and women [21-23]. Although it has been reported that there is a lack of evidence around gender exposure to different driving scenarios and driver expectations based on a persons' gender, some variations have been reported in relation to driving and driving cessation [23]. In general terms, women have been reported to be in better health than men when they give up driving and are reported as more likely to give up their licence voluntarily [22].

This research explores the potential of individuals to return to driving in the UK, in the presence of post stroke homonymous hemianopia, including the role of a mobility assessment course (MAC) in predicting which participants adapt to a high enough standard to consider a return to driving. We report a specific cohort of results in relation to returning to driving under the exceptional cases rule for visual field loss, under UK Driving and Vehicle Licensing Agency (DVLA) regulations. The cohort included are those who reported they were car drivers at the time of their stroke.

Data gathered for this research was collected as part of the Hemianopia Adaptation Study (HAST) which used the MAC to assess navigational skills in relation to adaptation which is reported elsewhere [24].

Research into the area of returning to driving with homonymous hemianopia is limited and inevitably involves the use of driving simulators rather than on-road assessments due to the legal restrictions surrounding the ability to assess driving skills in a real-life situation [20]. This research aims to add to the existing evidence base by including the driving outcomes and results from a clinical NHS based study.

Methods

This study is reported in accordance with the STROBE statement [25]. The clinical study was undertaken in accordance with the Tenets of Helsinki with NHS research ethical approval (16/NW/0542).

Patient and public involvement

Patients with experience of adapting to post-stroke visual field loss including individuals who had regained their driving licence through the exceptional cases rule were directly involved throughout the design, planning, conception and conduct of this study. They were involved in many ways including the development of patient information sheets, consultation on project design, attending the project steering committee and in the dissemination of results.

Design

A prospective observation case cohort design was used for the clinical study. The full eligibility criteria for the study are presented elsewhere [24]. In summary, individuals were eligible for inclusion if they were 18 years of age or older, had a clinical diagnosis of stroke and a new onset homonymous hemianopia (diagnosed within four weeks of stroke onset). A full routine medical and general history was recorded for all participants including general stroke signs and symptoms, date of stroke onset, stroke scan information, thrombolysis status, ocular signs and symptoms reported by the participant / carers, previous ophthalmic history, spectacle wear and driving status. A modified Barthel score was recorded for all participants at the baseline visit as a measure of stroke severity [26, 27]. The modified scale gives a score from 0 (totally dependent) to 20 (completely independent). Where possible a cognitive assessment score in the form of a Montreal Cognitive Assessment (MoCA) was documented at baseline to record the level of cognitive impairment [28]. Participant demographics including age, gender, ethnicity and postcode were collected. Using the participants' postcode, an income deprivation decile score was calculated using the Ministry of Housing, Communities and local government calculator [29].

Assessment

Each recruited participant underwent comprehensive vision assessment performed by the same orthoptist as reported elsewhere [24].

Routine specialist vision assessment comprised detailed assessments of case history, visual acuity, reading speed and accuracy, ocular alignment, binocular vision, visual fields and visual attention. Presence or absence of binocular vision was assessed using a combination of Bagolini glasses and Frisby stereotest.

A formal quantitative measure of visual field was undertaken where possible with an automated perimeter using a binocular Esterman programme. Where formal perimetry was not possible, a standardised confrontation method was employed using both static and kinetic target presentation, using a 1cm diameter red target. Grading of visual fields was undertaken by means of calculating a percentage of visual field loss to the hemianopic and unaffected sides. For the hemianopic side, the percentage of loss in the inferior and superior visual field areas was also calculated.

Visual attention was assessed using a combination of three paper-based tests: line bisection, clock drawing and cancellation tests. The combined results were used to make a clinical decision on the presence and extent of any visual inattention, coupled with clinical observations by the multidisciplinary team.

The MAC was used to measure navigational visual scanning, as fully described in the HAST results publication [24]. In summary, the MAC consists of 24 visual markers, 12 on the right side and 12 on the left side, located on corridor walls at varying heights and against a variety of backgrounds (Figure 1). (Figure one near here) Targets were positioned in equal standardised distribution at four different heights (30cm, 80cm, 130cm and 180cm). The course also contained two obstacles which consisted of standard wet floor signs, one on the right and one on the left side of the course at precise locations. Constant scanning was required throughout the course as targets were occasionally obscured from view (for example, behind heaters) and only visible when the participant had reached the target and not before. Participants were scored on the time taken to complete the course, number of target omissions to each side, total number of omissions and number of collisions to the standard obstacles. The percentage of total targets missed as well as the asymmetry score was recorded for each participant. The asymmetry score was calculated as the absolute difference between the number of omissions to the hemianopic and the unaffected / less affected side. In the full HAST results analysis, a baseline MAC % omissions cut-off score for predicting adaptation was developed. A cut-off of ≤25% target omissions was suggested to predict which individuals are likely to adapt to their hemianopia by 12-weeks post-stroke following gold standard care. This cut off score was developed by comparing the total percentage omissions for self-reported adapters and self-reported non-adapters at 12-weeks in the HAST study [24].

Collection of patient-reported outcome measures included the NEI VFQ-25 and Connor Davidson resilience scale questionnaires [30, 31]. The NEI VFQ-25 is a validated questionnaire that explores patient-reported difficulties in eleven vision-related areas in addition to a single general health rating question [30]. The Connor Davidson resilience scale was developed by Connor and Davidson in 2003 as a means of assessing an individual's level of resilience and adaptability [31]. In addition, fatigue severity was measured using the Fatigue Severity Scale (FSS) to explore the impact of fatigue on an individual's ability to adapt to visual loss [32].

Review appointments for the full study were made dependent on individual clinical need. Typically, this followed minimum national guidelines with review at 4, 12 and 26-weeks post-stroke onset [33]. Car drivers were offered an additional 1-year post-stroke assessment to consider referral for driving assessment. Only participants who wanted to be considered for referral to DVLA for driving assessment under the exceptional case criteria were offered the 1-year post-stroke appointment for further assessment.

Treatments offered

All participants were offered a mixture of standardised and targeted treatments and advice [33]. Standardised treatment included condition-specific information leaflets, paper-based scanning exercises and referral for registration of visual impairment [24, 34]. Scanning exercises comprised an A4 landscape card with a combination of horizontal and diagonal numbered circles radiating from a central fixation target [35]. Other relevant targeted management options were offered to participants on an individual needs-assessed basis including verbal advice, activity book / additional scanning exercises, reading aids such as typoscopes or line guides, yellow overlay for glare, web-based therapies (read-right or eye-search), driving advice or referral to other services [36-39].

In summary, all car drivers were offered gold standard treatment during their rehabilitation period which included a combination of scanning exercises and targeted advice [40].

Statistical methodology

Data analysis was performed in a systematic manner using univariate analysis (5% significance level) to compare various demographic, stroke-specific, vision-specific and MAC outcome variables with referral to DVLA status (referred versus not referred).

For categorical variables with a sufficient number of expected items (at least five) the Pearson's chi-squared test for association was used, otherwise the Fisher exact test was selected. For continuous variables, the two-sample t-test was used for data that was normally distributed or could be transformed to be normally distributed; otherwise using the Mann-Whitney U test.

Results

All participants were UK residents and therefore under legislation of the DVLA. The final study cohort consisted of 144 participants. Of these 144, 92 (63.9%) reported that they were car drivers at the time of their stroke, therefore 52 (36.1%) were not car drivers.

Of the 52 who were not car drivers, 29 (55.8%) had previously driven but given up prior to their stroke and the remaining 23 (44.2%) had never driven.

Figure 2 provides a summary flowchart of initial driving outcomes for the 92 car driver participants in the clinical study. (Figure two near here) A total of 23 car drivers were not included in the main analysis due to visual field recovery at final follow-up (n=10), group two drivers (n=6), missing follow-up data (n=4) and death before final follow-up (n=3). There were six participants who reported having a group two driving licence. All six were employed as heavy goods vehicle drivers at the time of their stroke and as a result of stroke had their group two licenses revoked by the DVLA. Of the six group two drivers, none were interested in pursuing a return to driving a car under group one regulations only.

Of the 69 remaining car drivers, 18 (26.1%) were not eligible for driving assessment under the exceptional cases rule due to a variety of reasons including reduced level of cognition, presence of visual inattention and reduced visual acuity (Figure 2).

Of the 51 participants who were eligible for driving assessment and therefore offered a 1-year assessment, only 13 (25.5%) accepted an appointment and attended for a 1-year review. The 38 participants who were eligible for assessment and subsequently declined had either lost confidence and felt they would be unsafe to return to driving or were not considering a return to driving for personal reasons. The majority of those who declined assessment at 1-year gave the reason as not feeling they had the confidence to consider a driving assessment at that time (n=34).

Comparison between eligible drivers who accepted / declined 1-year assessment

The participants who accepted a 1-year clinic appointment for consideration of referral to the DVLA for driving assessment (n=13), were compared to those who declined assessment (n=38). The two groups were compared in terms of their general demographics and characteristics (Table 1), stroke-specific information (Table 2) and vision-specific information (Table 3). In addition, the MAC outcomes were compared for the two groups (Table 4). (Tables 1-4 near here)

First, there was a significant difference in gender between the two groups (*p*=0.046), with the vast majority of those requesting assessment and hence referral to the DVLA being men (92.3%).

Participants who pursued referral had a slightly higher mean score on the Connor Davidson resilience scale (32.1) than those who did not (27.0). This indicates a slightly higher level of resilience with these participants, however, this difference was not statistically significant (*p*=0.115).

There was a statistically significant difference between the baseline Barthel scores for the two groups (*p*<0.001). All 13 referred to the DVLA had a baseline Barthel of the maximum score of 20, which suggests all had no limitations on their activities of daily living caused by stroke at baseline assessment.

A significant difference was found between groups with their self-reported visual function NEI VFQ-25 score (p=0.005). Those who were referred scored higher on average (66.1) than those who declined assessment (53.9) meaning they reported less detriment to their everyday lives caused by the visual impairment.

Last, all MAC outcomes were significantly different between the two groups. Those referred had a lower percentage of omissions (9.0%) than those not referred (28.3%). In addition, they completed the course in a faster median time (46.0 seconds) in contrast to those not referred (72.5 seconds). Baseline MAC asymmetry scores were lower in those accepting referral (1.4) than those declining (3.9).

Outcomes for eligible drivers referred for driving assessment

Of the 13 participants referred to the DVLA for consideration under the exceptional cases rule, 12 were issued with a provisional disability assessment licence (PDAL) to enable them to complete a driving assessment. All subsequently underwent driving assessment, with all 12 (100%) passing this process. All drivers who passed assessment received their driving licences back and returned to driving.

One driver of the 13 was refused issue of the PDAL for reasons unknown to the research or clinical team and not disclosed by the participant. The decision was unsuccessfully challenged by the participant, and he requested that no further action be taken.

Of the 12 successful drivers, 11 passed at first attempt whereas one driver undertook two assessments within a three-month period. Following first assessment, this driver received approval for three months of driving lessons using his PDAL prior to a re-test. It was deemed that this driver needed some further driving practice prior to a decision being made on driving ability and the impact of visual field loss. This driver subsequently passed his re-test and returned to driving with a full UK driving licence.

Participants returning to driving

A total of twelve study participants have passed specialist driving assessment under the exceptional cases rule for visual field loss and had their driving licences reinstated by DVLA. All 12 are white British, with 11 (91.7%) being men, with a mean age 61.0 years (SD 10.3). Right sided homonymous hemianopia was present in eight (66.7%) of the participants and left sided hemianopia in the remaining four (33.3%). Visual field loss on the hemianopic side ranged between 38.3% and 98.3% (mean 62.5%; SD 25.0). The length of time taken from referral to receipt of driving licence varied considerably, ranging from four to 12 months (mean 7.5 months; SD 3.2). Table 5 displays the characteristics for this group of drivers. (Table 5 near here)

The time point at which full adaptation was self-reported was also considered for these participants. Eight of the 12 participants (66.7%) reported they felt fully adapted to their visual field loss at 12-weeks post-stroke. A further two reported full adaptation by 26-week follow up (83.3%). These participants were required to wait until 1-year post-stroke for referral to the DVLA due to legal restrictions and strict criteria around this time point.

In addition, when considering the total percentage of target omissions on the MAC, nine of the 12 participants (75.0%) made no omissions at the 26-week week review as well as at the 1-year time point (Table 6). In fact, seven participants (58.3%) made no omissions at the earlier time point of 12-weeks. (Table 6 near here)

For the 12 participants who returned to driving, the mean baseline % MAC omissions was 9.4% (SD 3.7; range 0.0 – 20.8%) (Table 6).

Discussion

The results demonstrate that a proportion of drivers feel sufficiently adapted to post-stroke hemianopic visual field loss to consider pursuing a return to driving through the exceptional cases rule. There were several differences found between participants when comparing those who pursued a return to driving by requesting referral and those who did not. Despite the limited number of participants pursuing a return to driving in this study, the differences found are important for consideration in the likelihood of a person returning to driving with homonymous hemianopia.

In this research sample, the vast majority of participants requesting referral for exceptional cases rule were men (92.3%). This suggests a gender difference in those who pursue a return to driving. This gender difference in cessation of driving and acceptability of stopping is consistent with the literature which reports similar variation between genders, with women more likely than men to surrender their driving licence voluntarily [21, 22]. The reasons for this gender difference are not yet known and it is not possible to make assumptions here due to small sample sizes. It seems feasible that men have different reasons for wanting to return to driving as well as a different level of confidence to drive than women. It could be argued that driving is more important to the male identity than to females [21].

It is also worth considering that there may be other societal differences in the way men and women travel and access transport, providing further variation in the way they adapt to life without the ability to drive a car. These differences in turn have potential to influence decision making on a possible return to driving. For example, it has been reported that women typically are more dependent on walking and public transport than men as well as there being gender difference in the modes of public transport used [41]. Furthermore, women typically make more frequent, shorter journeys throughout the day whereas men typically make fewer but longer journeys. The reason for this is described as relating to the fact that women generally travel due to domestic and carer responsibilities whereas men are more likely to travel for work [41].

Socio-economic class and access to financial means could be a further factor influencing the decision to consider a return to driving. Those in a lower socio-economic class might not be in a financial position where a return to driving or owning a car is a viable option.

According to the Office for National Statistics, although the gender pay gap has seen a steady decline over previous years, the fact remains that men typically earn more than women [42]. This fact could contribute to a persons' individual desire to pursue a return to driving.

In addition, those who were referred for assessment appear to have a better level of adaptation to hemianopia reflected in mobility assessment scores, with less target omissions and a lower completion time. It seems feasible therefore that a combination of navigational adaptation and personality factors are important for individual decision making in relation to driving.

A further difference existed between Barthel scores, with those pursuing referrals all having a normal Barthel score of 20 indicating no co-existing stroke-related impairments. Participants who were eligible to apply for the exceptional cases rule, but declined assessment, had a lower mean Barthel score (16.7) indicating the presence of other impairments potentially likely to impact on driving ability. The exceptional cases rule involves a complex assessment process which could prove difficult or impossible for those with additional needs.

Participants who pursued referral had a slightly higher mean score on the Connor Davidson resilience scale than those who did not. This indicates a slightly higher level of resilience with these participants, however, this difference was not statistically significant and the impact of resilience on driving outcome warrants further exploration.

Those who requested referral had a higher mean NEI VFQ-25 score than those who declined referral. This demonstrates a lower self-reported impact on visual function and therefore better quality of life, in the group who requested referral. The NEI VFQ-25 is a self-reported measure and therefore must be used with caution where a potential return to car driving is being considered. Driving and the reality of losing the ability to drive on a permanent basis is a highly emotive issue. It is possible that self-reporting of symptoms is not a true reflection of impact for those who are desperate to drive again. It could potentially be seen as a threat to driving if the true impact of visual field loss was to be documented and as a result, car drivers may underestimate the extent of impact on their everyday life [21, 22].

In addition, the NEI VFQ-25 has limited use for a neurological cohort, with only one question directly related to driving. There is a neuro-ophthalmology supplement with additional 10 questions for the questionnaire, however this was not used for this study [43]. The reason for this is due to previous research showing that the neuro 10 supplement questions are heavily weighted towards ocular motility disorders and in fact, when a visual field loss is present, the true impact of this impairment can be underestimated [44].

There is evidence to support use of the MAC in the assessment of navigational adaptation. Using the baseline prediction of adaptation cut–off score of ≤25% omissions, all 12 participants who successfully returned to driving would have been predicted as adapting at baseline assessment. This reinforces the cut–off, as already described elsewhere, as a potentially reliable method of prediction for this purpose [24]. This cut-off score on MAC could be employed to determine those likely to adapt to hemianopia long-term and potentially return to driving.

Furthermore, there was a statistically significant difference found between MAC outcomes for those requesting referral for driving assessment and those declining. Due to the small numbers of participants requesting referral for driving assessment, clinical guidelines cannot be based on these findings alone and more research is recommended to explore this relationship further.

In addition, from analysis of driving outcomes, specific characteristics were found to be consistent with passing a driving assessment once referred. Participants who were confident in their ability to return to driving had their adaptation skills confirmed with all twelve passing a driving assessment and having their licences reinstated.

Those who passed assessment had a higher mean percentage of superior visual field loss (77.3%) in comparison to inferior loss (59.1%). This is an area of research already identified in the literature as requiring further investigation and could be a significant factor in a successful return to driving [12, 20]. Further research should investigate the likelihood of successful adaptation and return to driving in different patterns of visual field loss and fully investigate if any adaptations to vehicles can be made to make successful return more likely. The results from this research are based on a small sample size as the research main purpose was not centred around driving specifically, but centred on adaptation, meaning additional research is required to explore the area further.

It's worth mentioning that one of the criteria that must be fulfilled for exceptional cases is the requirement for a visual field defect to have been present for at least 12-months. There is a lack of evidence base to support this minimum requirement. For the 12 participants in this research who returned to driving successfully, eight (66.7%) reported adaptation at 12-weeks post-stroke. This suggests a potential for some people to perform a driving assessment sooner than the stipulated one year. This time frame is set out by driving legislation and would require more research before any review of this could be considered. Also, in relation to the time frame, the MAC outcome data provides some valuable insight. Of the 12 who passed driving assessment, nine (75%) made no omissions of targets on the MAC at 26-weeks post-stroke, with seven (58.3%) additionally seeing all the targets at 12-weeks post-stroke. Again, this suggests a level of adaptation prior to the one-year post-stroke time-period and reinforces the need for further exploration in this area. The need for an individual to have had a defect for one year does not allow for individual adaptation processes to be considered or for a personalised approach to rehabilitation.

It is, of course, not possible to ascertain the direct cause of this improvement in MAC omission scores over time in this cohort. Other factors are likely to contribute such as general interventions, family support, scanning experience, personality, time etc. Further exploration of this would be required in a larger cohort of patients.

In addition, for participants in this research, there was a large inequality in the way the application was handled by the DVLA. This resulted in a variation of time scales for issue of a PDAL and the resultant driving assessment. For participants in this study who were referred for consideration under exceptional cases rule, the time scale from referral to re-issue of driving licence varied between 4 and 12 months. This inconsistency caused considerable frustration and anxiety to the drivers concerned. For the participant whose application for exceptional cases took 12 months, this meant a period of two years without driving prior to his driving assessment. This poses an important issue for consideration, with this being a considerable amount of time without any driving experience; and having a likely impact on the driving assessment experience. The PDAL entitles the person to carry out the assessment only, under strict guidance. It does not allow for driving practice prior to assessment. It is likely that, in order to fully adapt to driving under new visual conditions, a person would benefit from experience of driving with the impairment, prior to the assessment itself. Indeed, one participant required a period of driving lessons and underwent two driving assessments.

There were a number of participants (n=38) who did not pursue a 1-year appointment to consider referral for driving assessment. One limitation of this research is that the reasons for this declining of appointment were not explored in any detail. Ideally, the reasons for this could have been further explored, including interviewing participants to fully analyse the reasoning behind their decisions and to explore if they could be supported through the process to allow better access. For example, participants were not asked about the driving status of their household specifically, only their own driving status. It seems likely that a number of reasons existed for the declining of referral, including other car drivers in the household, finances, occupation and social requirements. It is feasible to assume that someone who lives with another car driver could be less likely to need to return to driving, however this relationship was not explored within this research.

The authors propose some recommendations from the findings of this research. A recommendation is made to the driving regulatory bodies to:

- Consider reviewing and updating referral processes for individuals considering a return to driving with visual field loss, to make the systems more accessible and equitable for drivers, to reduce health inequalities currently present in access to driving assessment and decisions on safe return to driving.
- develop clear guidance on the confirmation of functional adaptation to contribute to the referral streamlining process.
- Support and develop research into the area of driving with visual field loss, involving affected individuals and relevant clinicians. This research should focus on the time scales for driving assessment and extent / position of visual field loss that is compatible with safe driving.

Further research is required with a specific focus on a return to driving with homonymous hemianopia and the time point at which adaptation is sufficient to allow a safe return to driving. The reasons for individuals not exploring the option of driving assessment should be explored in more detail. This research should involve the driving regulatory bodies and drivers with experience of visual impairment at every stage, to provide an evidence base for the current legislation.

Conclusions

In conclusion, it is possible for individuals with post-stroke homonymous hemianopia to return to driving, when exceptional cases criteria are met. It is therefore vital that individuals with post-stroke homonymous hemianopia are fully informed regarding driving regulations at an early stage and provided with the support and opportunity to consider a return to driving if appropriate. Due to the small numbers of participants requesting referral for driving assessment, clinical guidelines for return to driving cannot be based on these findings alone.

A further conclusion is that the MAC should be considered as a clinical measurement of adaptation in homonymous hemianopia. It has potential in the prediction of which individuals are likely to fully adapt to their visual impairment and as a result successfully return to driving. A recommendation is made for clinicians to include the MAC as part of their functional assessment for hemianopia. It is straight forward to set up with little time or equipment needed and can be replicated in most clinical settings.

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Table 1: General demographics and characteristics: referred to the DVLA at 52-weeks vs not referred (significant result)*

		Referred n=13	**Not referred** n=38	***p* value**
Age (years)	Mean (SD)	62.5 (11.1)	65.0 (13.4)	0.501
Gender	Men (%)	12 (92.3)	26 (68.4)	0.046*
	Women (%)	1 (7.7)	12 (31.6)	
Ethnicity	White British (%)	13 (100.0)	35 (92.2)	0.831
	Indian (%)	0 (0.0)	0 (0.0)	
	Pakistani (%)	0 (0.0)	1 (2.6)	
	Chinese (%)	0 (0.0)	1 (2.6)	
	Other white (%)	0 (0.0)	1 (2.6)	
Deprivation score	Mean (SD)	6.4 (2.2)	5.3 (3.0)	0.110
Living arrangements at baseline	Lives alone (%)	2 (15.4)	7 (18.4)	0.804
	Lives with someone (%)	11 (84.6)	31 (81.6)	
Resilience score (/40)	Mean (SD)	32.1 (7.5)	27.0 (10.6)	0.115
Occupation vision related	Yes (%)	12 (92.3)	32 (84.2)	0.464
	No (%)	1 (7.7)	6 (15.8)	

Table 2: Stroke-specific information: referred to the DVLA at 52-weeks vs not referred (significant result)*

		Referred **n=13**	**Not referred** **n=38**	***p* value**
Stroke type	Ischaemic (%)	13 (100.0)	37 (97.4)	0.555
	Haemorrhagic (%)	0 (0.0)	1 (2.6)	
Baseline Barthel score (/20)	Mean (SD)	20 (0.0)	16.7 (5.0)	<0.001*
Baseline MoCA score (/30) (n=19)	Mean (SD)	24.8 (3.0) n=5	23.4 (2.6) n=14	0.481
Side of hemianopia	Right (%)	8 (61.5)	23 (60.5)	0.949
	Left (%)	5 (38.5)	15 (39.5)	
Baseline Fatigue severity score (/63)	Mean (SD)	23.2 (19.0)	41.8 (20.7)	0.377

Table 3: Vision-specific information: referred for driving assessment at 52-weeks vs not referred (significant result)*

		Referred **n=13**	**Not referred** **n=38**	***p* value**
Total % baseline visual field loss	Mean (SD)	64.9 (26.9)	74.1 (24.3)	0.516
Superior % visual field loss at baseline	Mean (SD)	77.3 (18.3)	78.7 (21.1)	0.380
Inferior % visual field loss at baseline	Mean (SD)	59.1 (34/9)	71.9 (28.9)	0.169
Presence of binocular function	Yes (%)	13 (100.0)	32 (84.2)	0.127
	No / Unclear (%)	0 (0.0)	6 (15.8)	
Baseline reading speed (seconds) n=46	Mean (SD)	5.5 (1.1)	7.8 (3.7) n=33	0.057
Baseline Composite NEI VFQ-25 score	Mean (SD)	66.1 (9.1)	53.9 (18.5)	0.005*

Table 4: Mobility assessment outcomes: referred for driving assessment at 52-weeks vs not referred (significant result)*

		Referred **n=13**	**Not referred** **n=38**	***p* value**
Baseline Completion time (seconds)	Median (IQR)	46.0 (28)	72.5 (32)	0.006*
Baseline total % omissions	Mean (SD)	9.0 (6.6)	28.3 (9.9)	<0.001*
Baseline asymmetry score	Mean (SD)	1.4 (1.0)	3.9 (2.5)	0.001*

Table 5: Characteristics of participants who passed driving assessment

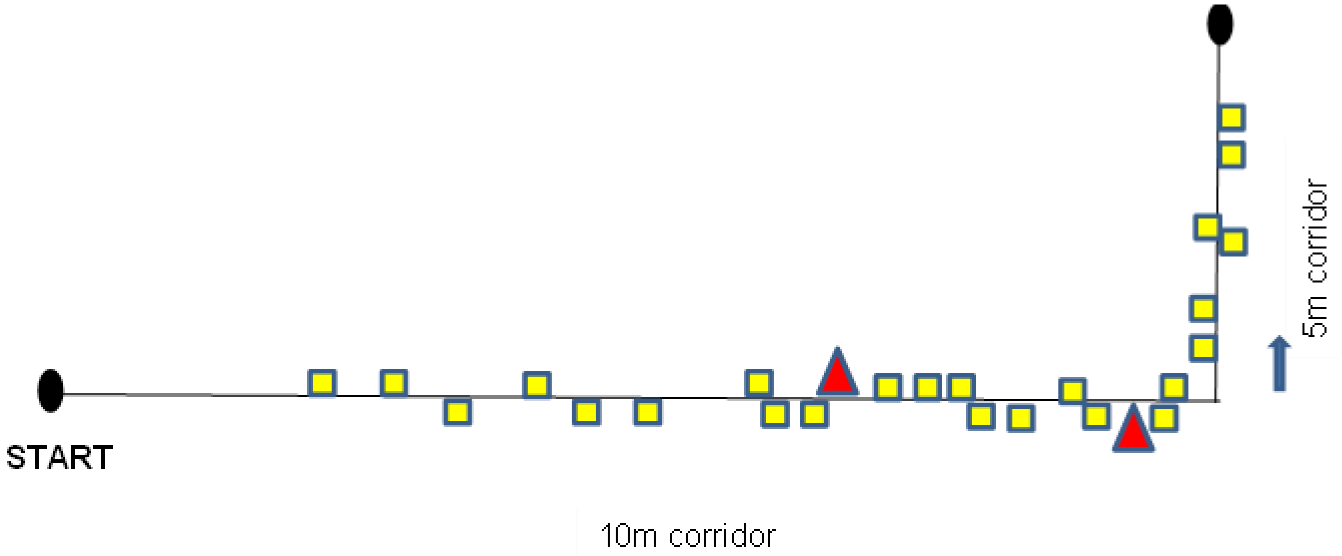
		Passed assessment (n=12)
Age (years)	Mean (SD)	61.0 (10.3)
Gender	Men (%)	11 (91.7)
	Women (%)	1 (8.3)
Living arrangements at baseline	Lives alone (%)	2 (16.7)
	Lives with someone (%)	10 (83.3)
Occupation vision related	Yes (%)	11 (91.7)
	No (%)	1 (8.3)
Side of hemianopia	Right (%)	8 (66.7)
	Left (%)	4 (33.3)
Total visual field loss (%)	Mean (SD)	62.5 (25.0)
Superior visual field loss (%)	Mean (SD)	75.9 (18.3)
Inferior visual field loss (%)	Mean (SD)	56.5 (35.1)

Table 6: Mobility assessment course outcomes for participants passing driving assessment (n=12)

Participant	**Baseline**	**12-weeks**	**26-weeks**	**52-weeks**
	total % omissions	**total % omissions**	**total % omissions**	**total % omissions**
1	0.0	0.0	0.0	0.0
2	8.3	0.0	0.0	0.0
2	4.2	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0
5	8.3	0.0	0.0	0.0
6	16.7	8.7	0.0	0.0
7	8.33	12.5	4.2	0.0
8	4.2	0.0	4.2	0.0
9	12.5	4.2	0.0	0.0
10	20.8	8.3	0.0	0.0
11	12.5	0.0	0.0	0.0
12	16.7	4.2	8.3	0.0

Figure 1: Mobility assessment course (MAC) layout plan

Diagram representation of the mobility assessment course layout, which consists of a 10m corridor followed by a sharp turn and a further 5m corridor, with 24 visual markers on the wall. The visual markers are distributed in a standardised pattern at various heights.



 - marker to be identified by participant. Markers are laminated yellow cards (size 10 x 10 cm) attached to the wall and placed at pre-defined heights.

 - Obstacles (wet floor signs) to be placed directly onto hospital corridor at set distances of 6m and 9m, one on the right side and one on left.

 - Directional arrow (2cm black arrow against a yellow background).

Figure 2: Driving outcome flowchart for car driver participants in the study

Diagram flowchart of driving outcomes including numbers excluded from analysis (n=23), numbers eligible for driving assessment (n=51) and numbers not eligible for driving assessment (n=18) including reasons for ineligibility (to include cognition, reduced visual acuity, visual inattention and other conditions).