NEURO-OPHTHALMOLOGY
2017, VOL. 41, NO. 6, 297–305
https://doi.org/10.1080/01658107.2017.1337159

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REVIEW

Clinical versus Evidence-based Rehabilitation Options for Post-stroke Visual Impairment

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ABSTRACT

The aim of this study was to identify which treatments for post-stroke visual impairment have a supportive evidence base, and which are being used in practice without supportive evidence. A systematic review of the literature reporting on the available treatment options was compared against the visual treatments used in the Vision In Stroke (VIS) study. Treatments were identified for visual field, visual neglect, visual perception and ocular motility disorders. Visual scanning therapies for hemianopia and neglect have an established evidence base. However, a number, such as typoscopes and advice options, have limited detail of their effectiveness and require further research.

ARTICLE HISTORY
Received 24 April 2017
Revised 22 May 2017
Accepted 29 May 2017

KEYWORDS
Management; stroke; treatment; vision; visual impairment

Introduction

Visual impairment following stroke affects approximately 65% of stroke survivors[1] and can include abnormalities of central and/or peripheral vision, eye movements, and a variety of visual perception problems such as inattention and agnosia.[2] These impairments can have wide-reaching implications on daily living, independence, and quality of life. Links with depression have also been reported.[3–7]

There are a wide variety of treatments available for post-stroke visual impairment, including low vision aids,[8] visual scanning training for visual field loss,[9,10] and prisms or occlusion for strabismus and ocular motility defects.[11]

In order to achieve the highest quality of care for these patients, it is essential to use those treatments with recommendations through high-quality clinical research. Evidence-based practice improves the consistency of care and is vital in ensuring that patients receive interventions of proven benefit, which subsequently improve the patients' overall quality of life.[12] Furthermore, evidence-based practice is beneficial in reducing the risk of harmful or unnecessary care.[13] Systematic reviews are described as the frequent starting point in developing guidelines to implement change into clinical practice.[14,15]

However, despite it being widely accepted that research drives better clinical practice, there is evidence to suggest that some health professionals still do not change their practice to meet the demands in the current literature.[13] Reasons for this may include lack of time for evidence-based practice activities including reading research articles, health professionals' attitude towards research, and the health care professionals' previous level of education.[13,16,17] One study looking at the use of evidence-based practice in nursing suggested the use of teaching and leadership to support and encourage clinicians to change their current practice as a result of research findings.[17] Another recommends that to successfully implement evidence into clinical practice, clinicians must be informed of the guidelines and materials, acknowledge and understand these guidelines, and have these materials in their possession.[18]

The aim of this literature review is to compare the treatments used in a large, visually impaired stroke cohort, taken from the most recent, major vision and stroke (Vision In Stroke [VIS]) study,[19] against the treatment options identified in a

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comprehensive synthesis of the published literature. This will identify

(1) The treatment options with an existent evidence base substantiated by comparative trial/case-control research.
(2) The treatment options with an established evidence base substantiated by observational clinical research.
(3) The treatment options based on clinical experience but are, as yet, lacking a substantive research evidence base.

As a result, it will be possible to provide recommendations of interventions to clinicians treating stroke survivors with visual impairment, based on those treatments with adequate supporting evidence. This review will further highlight those treatments with a weak/complete lack of evidence, thus to caution clinicians of the potential risk in using these treatments without substantial supportive evidence through further research.

Methods

We aimed to compare the visual interventions reportedly used in a large, visually impaired stroke cohort (the VIS study) against the treatment options identified in a comprehensive synthesis of the published literature.

A systematic review of the literature was conducted including randomised controlled trials, controlled trials, cohort studies, observational studies, and retrospective reviews. The included articles were subject to quality and risk-of-bias analyses using the appropriate statement dependent on the type of article. Subjects included adult participants (aged 18 years or over) with visual impairment as a direct result of stroke. The full description of the methods used in this systematic review and the results of the quality analysis of the included articles have been published elsewhere.[20] Studies that included mixed populations were included if over 50% of the participants had a diagnosis of stroke and were discussed separately. Scholarly online resources were searched, and articles and registers of published, unpublished, and ongoing trials were hand searched (http://pcwww.liv.ac.uk/~rowef/index_files/Page646.htm).

The Vision In Stroke (VIS) study was a prospective, observational multi-centre cohort study that aimed to review and define the visually impaired stroke population, to determine the prevalence of post-stroke visual impairments and identify the associations and outcomes for this population. A total of 915 stroke survivors were recruited from 20 recruiting sites in the UK. They were ≥18 years old and suspected of having a visual impairment. Of the 915 recruits, 92% (n = 840) had a confirmed visual impairment. Standardised referral and investigation protocol included assessment of patient demographics, stroke and ocular history, visual acuity, ocular alignment and motility, visual field, and visual perception, with capture of treatment options. A full description of the methods and materials used in this study are published elsewhere.[19]

Results

Figure 1 illustrates the results of the search. Forty-four articles (2698 participants and 529 health care professionals) were included. This number includes 4 Cochrane reviews, 7 randomised trials, 1 randomised crossover trial, 2 non-randomised controlled trials, 22 prospective observational studies, 3 retrospective analysis, 4 prospective surveys/questionnaires, and 1 prospective observational study with a questionnaire.

A total of 44 articles were included in this review paper, and the quality of evidence was assessed for each (see Hanna et al.[20] for full results). The included articles reported on interventions for one or a combination of two or more visual impairments; therefore, some studies have been counted more than once in the following breakdown.

Treatment options identified for visual field loss included visual search training (7 randomised controlled trials [RCTs], 1 case series, 8 prospective observational studies, 2 retrospective reviews, 1 controlled trial, and 2 surveys), Peli prisms (2 RCTs, 2 randomised crossover trials, and 1 prospective observational study), and restitution therapy (5 RCTs, 2 randomised crossover trials, 10 prospective observational studies, and 2

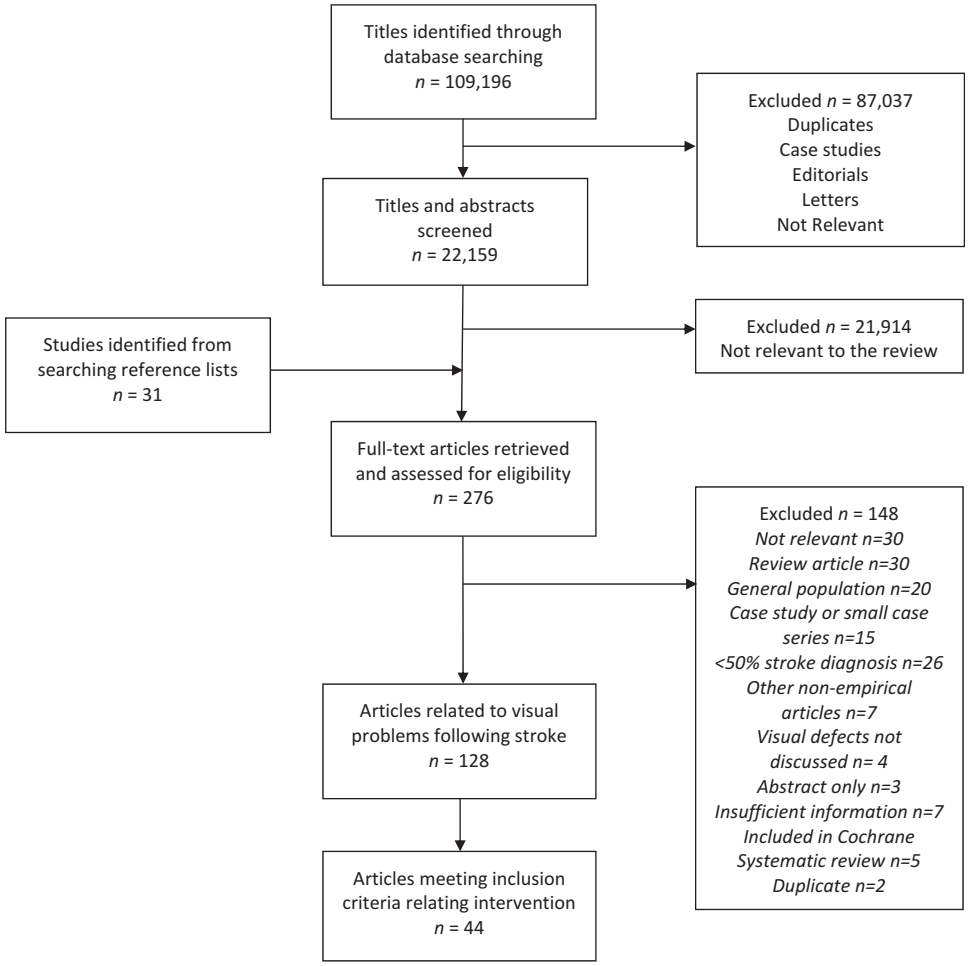

Figure 1. Flowchart of pathway to inclusion of articles.

retrospective reviews). Treatment options for visual neglect included hemifield eye patching (4 RCTs, 1 prospective observational study and 2 surveys) and scanning treatment (17 RCTs and 3 surveys), whereas word recognition training for alexia was the only other perceptual treatment reported (1 prospective observational study). Treatment options for ocular motility disorders included prisms (1 prospective observational study and 2 surveys), occlusion (1 prospective observational study and 2 surveys), and pharmacological methods (1 RCT, 1 randomised crossover trial, and 1 survey). Finally, treatments identified for reduced central vision included spectral filters (1 RCT), refractive correction (2 prospective observational studies), reading aids (1 survey), and advice (1 survey). These figures are inclusive of the articles discussed within the 4 Cochrane systematic reviews.

VIS recruited 915 patients with a mean age of 69 years (SD = 14). Ninety-two percent (n = 840) of the cohort had visual impairment and all received treatment or advice for this. Interventions consisted of verbal or written advice (99%), refraction (39.3%), prisms (12%), typoscopes (8.9%), occlusion (7.8%), and low vision aids (3.8%).

Discussion

Visual field loss

Treatment for visual field loss can be subcategorised into compensatory, substitutive, and restitutive methods.[21]

Compensatory

The literature search found that verbal or written advice was the most common strategy for visual

field loss in a survey in Scotland,[22] whereas advise on head postures was reported as the second most common treatment in a Cochrane review (64%).[22] Additional treatment methods identified through the review included computer- and paper-based scanning training programmes and word search games, which were supported by high-quality trial research.[23–26] These included two free-to-access online computer-based scanning therapies: Eye-search[27] and Read-right.[28] Moreover, verbal advice for compensation of the visual field loss and registration for formal certification of visual impairment were reported by Freeman and Rudge[29] through observational research.

Concurrently, the VIS study further reported the use of the above treatments, with advice as the most common approach (n = 474). This consisted of raising awareness of the field loss, reading strategies, scanning eye and head movements, use of lighting, compensatory head posture, and registration for visual impairment.

There is a crossover between active training of scanning as a treatment option and provision of advice on how to access and undertake home-based training.

Additional compensatory therapies used in practice included refraction (n = 85), low vision aids (n = 20), typoscopes (n = 42), and orthoptic exercises (n = 8).

Substitutive

Peli prisms were the only substitutive treatment identified from the literature search[30,31] and were the most commonly prescribed treatment for field loss in a recent Cochrane review.[22] Likewise, Peli prisms were the only substitutive treatment utilised in the clinical study and were offered to 6% of their stroke survivors with visual field loss (n = 29).[32]

Restitutive

Visual restoration therapy involves presenting a light stimulus to the border area of the visual field loss.[21] It has been found to show an expansion of the visual field in many of the reporting articles,[33–37] although significant variations in length of treatment sessions suggests validation of this method through further research.[10,38,39] No two studies prescribed exactly the same amount of training, rendering it difficult to make direct comparisons. The VIS study did not report on restitutive therapies as this type of treatment was not offered in National Health Service (NHS) centres.[32]

Clinical recommendations for the treatment of visual field loss following stroke

Overall, a variety of interventions have been reported in the literature for the treatment of visual field loss, although not enough high-quality research exists to decipher the true efficiency of a number of these treatment options, mostly in relation to many of the substitutive and restitutive treatments. Therefore, the current recommendations from the literature are for compensatory search strategies to treat post-stroke visual field loss. Peli prisms have an existing evidence base through high-quality research, although they were used less frequently in clinical practice compared with search strategies, indicating better compliance or success with the paper- or Web-based training.

The majority of the VIS study population were offered compensatory treatment in the form of verbal advice and compensation techniques, although there is a weak evidence base to support this, highlighting an area for further research to clarify the content and form of this advice.

Reduced central vision

The results of the review conveyed the importance of ensuring that stroke survivors have access to their glasses in hospital or receive retest for glasses after discharge.[40] However, the authors did not report whether or not this had any quantitative improvement to the patients' quality of life or activities of daily living. Additionally, coloured filters were described in a randomised control trial or stroke survivors and healthy controls, in cases where reduced visual acuity persists after refractive correction.[41] Magnifiers and reading aids have been reported in the literature as aids for reduced central vision. Although the treatment would be similar for those post-stroke, the use of these aids has not been validated within this population specifically.

The use of refraction to treat reduced visual acuity was furthered in the VIS study (n = 50), although, again, the authors did not report improvement of the patients' quality of life or activities of daily living. Furthermore, low vision aids (n = 2), typoscopes (n = 1), and verbal advice (n = 6) including recommendations of lighting, ensuring they have their glasses, and eccentric viewing (in which the patient practices non-foveal viewing in cases of central scotoma)[42] were provided to the patients in the VIS study with reduced central vision. Additionally, one patient received lubrication for dry eye after a facial nerve palsy.

Clinical recommendations for the treatment of reduced central vision following stroke

Overall, advice, refraction, and visual aids may be of significant clinical benefit to stroke survivors with central visual impairment. However, many of these have not yet been evaluated within a specific stroke population. Further research is required to determine the benefit of these therapies following stroke, considering improvements to quality of life and activities of daily living. Spectral filters were not offered in the VIS study, although their use in the literature was not entirely favourable, possibly indicating a poor clinical benefit, which prevents recommendation of this treatment without further validation of its efficacy.

Ocular motility defects

Few articles reported on ocular motility treatment specifically after stroke. One Cochrane review discussed pharmacological interventions for post-stroke nystagmus, as no randomised trials relating to restitutive, compensatory, or substitutive treatments were found for stroke populations with other ocular motility disorders.[43–45] It was reported that gabapentin and baclofen were used most often to treat symptoms of nystagmus, with both showing significant clinical benefits and yielding similar risk of side effects, although gabapentin was estimated to be slightly more effective in improving visual acuity than baclofen.[46]

Furthermore, prisms and occlusion have a supportive evidence through observation studies. However, interventions such as prisms and occlusion for diplopia do not necessitate an RCT to prove their efficacy, as their effect on alleviating diplopia is clear-cut.[11,43] In a practice survey, Fresnel prisms to resolve the symptom of diplopia were identified as the most common management for post-stoke ocular motility defects (93%), followed by advice on head postures (64%) and convergence exercises (50%).[22]

The most common treatment prescribed in the VIS study for ocular motility defects was occlusion of one eye to eradicate diplopia (n = 41), followed by refraction (n = 22), prisms for diplopia (n = 27), and orthoptic exercises (n = 1). Advice was given to 33% (n = 69) on lighting, head postures, reading aids, and improve awareness of visual status.[47,48] Moreover, certification of visual impairment registration was discussed as a further option for those whose eye movement restrictions are impacting on daily activities.[48] Treatment for nystagmus largely consisted of alleviating the symptoms of diplopia, blurred vision, and reading difficulties.[47] No drug therapies were offered for the treatment of oscillopsia in the VIS study.

Further options were discussed by the authors as potential alternative treatments but were not required at the time of the VIS study. These included yoked prisms (which shift images towards a central position where there is an inability to move gaze in one direction), extra ocular muscle botulinum toxin, and surgery.[48]

Clinical recommendations for the treatment of ocular motility defects following stroke

Although some of the treatment options for eye movement disorders, such as surgery and botulinum toxin, have not been established within a stroke population specifically, the benefit is likely to be much the same as with other brain injury cohorts. Furthermore, the lack of high-quality clinical trials to determine the efficacy of treatments such as prisms and occlusion may not necessarily be required. It is well established that these treatments will alleviate the symptoms of diplopia without the need of clinical trials to prove so. Therefore, it would seem reasonable to recommend the use of these treatments for post-stroke ocular motility defects.

Visual perception (including neglect/inattention)

Most perceptual interventions identified through the search were for the treatment of visual neglect.

Substitutive

Substitutive treatments included typoscopes and non-computerised scanning therapy, although a description of these scanning therapies was not provided.[22] A randomised controlled trial compared "forced-use" therapies, hemifield eye patching, and optokinetic stimulation (OKS) in which sector occlusion is placed over the non-neglecting side of lenses.[49]

Compensatory

A survey found that non-computerised scanning training along with provision of aids and modifications were largely offered to treat visual neglect (89%).[50] One study found added benefits from smooth pursuit therapy when compared with standard scanning therapy.[51] Additional compensatory methods found through the literature search included occlusion[52] and prism adaptation.[53] The only other perceptual treatment reported was cross-modal word recognition training for the treatment of alexia.[54]

Perceptual treatments offered in the VIS study consisted of refraction (n = 8) and advice (n = 88). The authors report their awareness of the use of monocular or sector prisms and occlusion to treat visual neglect but did not use these treatment methods in their study population. Treatment largely consisted of advice on scanning strategies, compensatory head postures, and general awareness.[55] For those with visual agnosia, patients benefitted from specific information along with compensatory strategies and for those with Charles Bonnet syndrome, reassurance and explanation that the visual hallucinations did not signify mental illness were extremely beneficial.[55]

Clinical recommendations for the treatment of ocular motility defects following stroke

A broad range of visual perceptual disorders can occur following stroke; however, very few treatments other than those for visual neglect have been discussed in the current literature. It is possible that a number of treatments including verbal and written advice are being used in practice with no clear evidence base, and as such, further research is required to establish these treatments and provide clear recommendations for practicing clinicians.

A number of treatments for neglect have an existing evidence base, although they were not used in clinical practice. Reasons for this may be that the evidence for these treatments came after the dates of the VIS study, such as those for hemifield eye patching, whereas others such as prism adaptation may be perceived as unfavourable through previous clinical experience. Further research is required before recommendations for their use can be made.

Conclusions

Many of the orthoptic treatment options offered to stroke survivors with visual impairment matched those identified through the systematic literature review, with the exception of visual restorative therapy, which is not an available treatment within the UK National Health Service. As the VIS study predates some of the treatments discussed in the included review articles, e.g., hemifield eye patching and word recognition training,[49,54] it is possible that these treatments are now being used more frequently in clinical practice.

Refraction was performed frequently on patients with all types of visual impairment in the VIS study and not only for those with reduced central vision, indicating that achieving best corrected visual acuity was an important outcome for most patients. Many complained of altered vision despite good objective visual acuity measurements. This was often due to out-of-date refractive correction and not as a result of the stroke itself, leading to higher numbers receiving refraction after stroke consistent with good clinical practice.

Visual scanning training for the treatment of neglect and visual field loss has the strongest evidence base with comparative trials or case-control research; therefore, clear recommendations can be made for these treatments. Treatments with good clinical evidence sustained by observational clinical research include prisms and occlusion for diplopia. Furthermore, typoscopes, verbal advice, and orthoptic exercises are most commonly based on clinical experience only, and although they may have significant clinical benefits to stroke survivors with visual impairments, further research is required to establish the timing, frequency, and

form in which this advice is given before recommendations can made to practicing clinicians.

Where a number of treatment options exist for a given visual deficit, it is important to use the options that are supported with an evidence base through trial research, e.g., visual scanning for hemianopia and various drugs for nystagmus. However, it is of equal importance to use treatment options with well-established clinical research evidence, such as prisms and occlusion, that, both objectively and subjectively, alleviate symptoms of diplopia and therefore do not warrant trials to establish their efficacy. However, other options such as verbal advice and visual aids are used clinically based on experience alone and require further research to demonstrate their efficacy and superiority over other rehabilitation methods. This will provide orthoptists and other allied health professionals treating visual impairment after stroke with a substantial evidence base in which they can make informed decisions on the best choice of treatment, whilst deterring the use of unnecessary or ineffective treatments.

Funding

This research is funded by the National Institute of Health Research (CLAHRC NWC). The second author in this review article (F.R.) was the lead author in the VIS study. The views expressed are those of the authors and not necessarily those of the NHS, the NIHR, or the Department of Health.

Declaration of interest

One author (F.R.) led the Vision In Stroke (VIS) study discussed in this article. The authors alone are responsible for the content and writing of the article.

References

[1] Hepworth LR, Rowe FJ, Walker MF, Rockliffe J, Noonan C, Howard C, Currie J. Post-stroke visual impairment: a systematic literature review of types and recovery of visual conditions. *Ophthalmol Res* 2016;5:1–43.

[2] Rowe F, Brand D, Jackson CA, Price A, Walker L, Harrison S, Eccleston C, Scott C, Akerman N, Dodridge C, Howard C, Shipman T, Sperring U, MacDiarmid S, Freeman C. Visual impairment following stroke: do stroke patients require vision assessment? *Age Ageing* 2009;38:188–193.

[3] Granger CV, Cotter AC, Hamilton BB, Fiedler RC. Functional assessment scales: a study of persons after stroke. *Arch Phys Med Rehabil* 1993;74:133–138.

[4] Nelles G, Esser J, Eckstein A, Tiede A, Gerhard H, Diener HC. Compensatory visual field training for patients with hemianopia after stroke. *Neurosci Lett* 2001;306:189–192.

[5] Ramrattan RS, Wolfs RCW, Panda-Jonas S, Jonas JB, Bakker D, Pols HA, Hofman A, De Jong PTVM. Prevalence and causes of visual field loss in the elderly and associations with impairment in daily functioning: The Rotterdam Study. *Arch Ophthalmol* 2001;119:1788–1794.

[6] West CG, Gildengorin G, Haegerstrom-Portnoy G, Schneck ME, Lott L, Brabyn JA. Is vision function related to physical functional ability in older adults? *J Am Geriatr Soc* 2002;50:136–145.

[7] Tsai SY, Cheng CY, Hsu WM, Su TP, Liu JH, Chou P. Association between visual impairment and depression in the elderly. *J Formosan Med Assoc* 2003;102:86–90.

[8] Virgili GAR, Grover LL, Bentley SA, Giacomelli G. Reading aids for adults with low vision [review]. *Cochrane Database Syst Rev* 2013;(10):CD003303.

[9] Pambakian A, Currie J, Kennard C. Rehabilitation strategies for patients with homonymous visual field defects. *J Neuro-Ophthalmol* 2005;25:136–142.

[10] Zihl J, von Cramon D. Restitution of visual field in patients with damage to the geniculostriate visual pathway. *Hum Neurobiol* 1982;1:5–8.

[11] Firth AY, Whittle JP. Clarification of the correct and incorrect use of ophthalmic prisms in the measurement of strabismus. *Br Orthopt J* 1994;51:15–18.

[12] Woolf S, Grol R. Clinical guidelines: potential benefits, limitations, and harms of clinical guidelines. *BMJ Clin Res* 1999;318:527–530.

[13] Grol R, Grimshaw J. From best evidence to best practice: effective implementation of change in patients' care. *Lancet* 2003;362:1225–1230.

[14] Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *J Clin Epidemiol* 2009;62:1006–1012.

[15] Sampson M, McGowan J, Cogo E, Grimshaw J, Moher D, Lefebvre C. An evidence-based practice guideline for the peer review of electronic search strategies. *J Clin Epidemiol* 2009;62:944–952.

[16] Hannes K, Vandersmissen J, De Blaeser L, Peeters G, Goedhuys J, Aertgeerts B. Barriers to evidence-based nursing: a focus group study. *J Adv Nurs* 2007;60:162–171.

[17] Johansson B, Fogelberg-Dahm M, Wadensten B. Evidence-based practice: the importance of education and leadership. *J Nurs Manage* 2010;18:70–77.

[18] Grol R. Successes and failures in the implementation of evidence-based guidelines for clinical practice. *Med Care* 2001;39(8, Suppl 2): 46–54.

[19] Rowe F, Wright D, Brand D, Jackson C, Harrison S, Eccleston C, Maan T, Scott C, Vogwell L, Peel S, Robson L, Akerman N, Dodridge C, Howard C, Shipman T, Sperring U, Yarde S, Rowe F, MacDiarmid S, Freeman C. Prevalence of ocular motor cranial nerve palsy and associations following stroke. *Eye* 2011;25:881–887.

[20] Hanna KL, Hepworth LR, Rowe FJ. The treatment methods for post-stroke visual impairment: a systematic review. *Brain Behav* 2017;xx:e00682.

[21] Pollock A, Hazelton C, Henderson CA, Angilley J, Dhillon B, Langhorne P, Livingstone K, Munro FA, Orr H, Rowe F, Shahani U. Interventions for visual field defects in patients with stroke. *Stroke* 2012;43:e37–e38.

[22] Pollock A, Hazleton C, Brady M. Orthoptic assessment and management of patients with stroke in Scotland. *Br Ir Orthopt J* 2011;8:36–42.

[23] Pollock A, Hazelton C, Henderson CA, Angilley J, Dhillon B, Langhorne P, Livingstone K, Munro FA, Orr H, Rowe FJ, Shahani U. Interventions for visual field defects in patients with stroke. *Cochrane Database Syst Rev* 2011;(10):CD008388.

[24] Aimola L, Lane AR, Smith DT, Kerkhoff G, Ford GA, Schen T. Efficacy and feasibility of home-based training for individuals with homonymous visual field defects. *Neurorehabil Neural Repair* 2014;28:207–218.

[25] Mazer BL, Sofer S, Korner-Bitensky N, Gelinas I, Hanley J, Wood-Dauphinee S. Effectiveness of a visual attention retraining program on the driving performance of clients with stroke. *Arch Phys Med Rehabil* 2003;84:541–550.

[26] Hayes A, Chen CS, Clarke G, Thompson A. Functional improvements following the use of the NVT Vision Rehabilitation program for patients with hemianopia following stroke. *Neurorehabilitation* 2012;31:19–30.

[27] Ong Y-H, Jacquin-Courtois S, Gorgoraptis N, Bays PM, Husain M, Leff AP. Eye-Search: a web-based therapy that improves visual search in hemianopia. *Ann Clin Transl Neurol* 2015;2:74–78.

[28] Ong YH, Brown MM, Robinson P, Plant GT, Husain M, Leff AP. Read-Right: a "web app" that improves reading speeds in patients with hemianopia. *J Neurol* 2012;259:2611–2615.

[29] Freeman CF, Rudge NB, eds. *The Orthoptist's Role in the Management of* Stroke Patients. 6th International Orthoptic Congress; Harrogate, UK; 29–30th June, 12–2nd July 1987. London, UK: International Orthoptic Association.

[30] Giorgi RG, Woods RL, Peli E. Clinical and laboratory evaluation of peripheral prism glasses for hemianopia. *Optom Vis Sci* 2009;86:492–502.

[31] Bowers AR, Keeney K, Peli E. Randomized crossover clinical trial of real and sham peripheral prism glasses for hemianopia. *JAMA Ophthalmol* 2014;132:214–222.

[32] Rowe F, Wright D, Brand D, Jackson C, Harrison S, Maan T, Scott C, Vogwell L, Peel S, Akerman N, Dodridge C, Howard C, Shipman T, Sperring U, MacDiarmid S, Freeman C. A prospective profile of visual field loss following stroke: prevalence, type, rehabilitation and outcome. *BioMed Res Int* 2013;719096:1-12.

[33] Mueller I, Mast H, Sabel BA. Recovery of visual field defects: a large clinical observational study using vision restoration therapy. *Restor Neurol Neurosci* 2007;25:563–572.

[34] Poggel DA, Müller-Oehring EM, Gothe J, Kenkel S, Kasten E, Sabel BA. Visual hallucinations during spontaneous and training-induced visual field recovery. *Neuropsychologia* 2007;45:2598–2607.

[35] Romano JG, Schulz P, Kenkel S, Todd DP. Visual field changes after a rehabilitation intervention: vision restoration therapy. *J Neurol Sci* 2008;273:70–74.

[36] Sabel BA, Kruse R, Wolf F, Guenther T. Local topographic influences on vision restoration hot spots after brain damage. *Restor Neurol Neurosci* 2013;31:797–803.

[37] Sabel B, Kenkel S, Kasten E. Vision restoration therapy (VRT) efficacy as assessed by comparative perimetric analysis and subjective questionnaires. *Restor Neurol Neurosci* 2004;22:399–420.

[38] Zihl J, von Cramon D. Restitution of visual function in patients with cerebral blindness. *J Neurol Neurosurg Psychiatry* 1979;42:312–322.

[39] Schmielau F, Wong EK Jr. Recovery of visual fields in brain-lesioned patients by reaction perimetry treatment. *J Neuroeng Rehabil* 2007;4:1–16.

[40] Lotery AJ, Wiggam MI, Jackson AJ, Silvestri G, Refson K, Fullerton KJ, Gilmore DH, Beringer TRO. Correctable visual impairment in stroke rehabilitation patients. *Age Ageing* 2000;29:221–222.

[41] Beasley IG, Davies LN. The effect of spectral filters on visual search in stroke patients. *Perception* 2013;42:401–412.

[42] Jeong JH, Moon NJ. A study of eccentric viewing training for low vision rehabilitation. *Korean J Ophthalmol* 2011;25:409–416.

[43] Pollock A, Hazelton C, Henderson CA, Angilley J, Dhillon B, Langhorne P, Livingstone K, Munro FA, Orr H, Rowe FJ, Shahani U. Interventions for disorders of eye movement in patients with stroke. *Cochrane Database of Syst Rev* 2011;(10):CD008389.

[44] Leigh RJ, Burnstine TH, Ruff RL, Kasmer RJ. Effect of anticholinergic agents upon acquired nystagmus: a double-blind study of trihexyphenidyl and tridihexethyl chloride. *Neurology* 1991;41:1737–1741.

[45] Strupp M, Schuler O, Krafczyk S, Jahn K, Schautzer F, Buttner U, Brandt T. Treatment of downbeat nystagmus with 3,4-diaminopyridine: a placebo-controlled study. *Neurology* 2003;61:165–170.

[46] Choudhuri I, Sarvananthan N, Gottlob I. Survey of management of acquired nystagmus in the United Kingdom. *Eye* 2007;21:1194–1197.

[47] Rowe F, Brand D, Jackson C, Price A, Walker L, Harrison S, Eccleston C, Scott C, Akerman N, Dodridge C, Howard C, Shipman T, Sperring U, MacDiarmid S, Freeman C. The spectrum of nystagmus following cerebro-vascular accident. *Br Ir Orthopt J* 2008;5:22–25.

[48] Rowe F, Wright D, Brand D, Jackson CA, Harrison S, Maan T, Scott C, Vogwell L, Peel S, Akerman N, Dodridge C, Howard C, Shipman T, Sperring U, MacDiarmid S, Freeman C. Profile of gaze dysfunction following cerebrovascular accident. *ISRN Ophthalmol* 2013;264604, 1–18.

[49] Machner B, Dorr M, Sprenger A, von der Gablentz J, Heide W, Barth E, Helmchen C. Impact of dynamic bottom-up features and top-down control on the visual exploration of moving real-world scenes in hemispatial neglect. *Neuropsychologia* 2012;50:2415–2425.

[50] Pollock A, Hazelton C, Brady M. Visual problems after stroke: a survey of current practice by occupational therapists working in UK stroke inpatient settings. *Top Stroke Rehabil* 2011;18(Suppl 1):643–651.

[51] Kerkhoff G, Reinhart S, Ziegler W, Artinger F, Marquardt C, Keller I. Smooth pursuit eye movement training promotes recovery from auditroy and visual neglect: a randomised controlled study. *Neurorehabil Neural Repair* 2013;27:789–798.

[52] Beis J-M, André J-M, Baumgarten A, Challier B. Eye patching in unilateral spatial neglect: efficacy of two methods. *Arch Phys Med Rehabil* 1999;80:71–76.

[53] Datié AM, Paysant J, Destainville S, Sagez A, Beis JM, André JM. Eye movements and visuoverbal descriptions exhibit heterogeneous and dissociated patterns before and after prismatic adaptation in unilateral spatial neglect. *Eur J Neurol* 2006;13:772–779.

[54] Woodhead ZVJ, Penny W, Barnes GR, Crewes H, Wise RJS, Price CJ, Leff AP. Reading therapy strengthens top-down connectivity in patients with pure alexia. *Brain* 2013;136:2579–2591.

[55] Rowe F, Brand D, Jackson C, Price A, Walker L, Harrison S, Eccleston C, Scott C, Akerman N, Dodridge C, Howard C, Shipman T, Sperring U, MacDiarmid S, Freeman C. Visual perceptual consequences of stroke. *Strabismus* 2009;17:24–28.