EVALUATION OF READING PERFORMANCES IN PATIENTS WITH PRIMARY GLAUCOMA ACCORDING TO SEVERITY OF VISUAL FIELD DEFECT USING DAILY READING MATERIALS

DR JASVINJEET KAUR SIDHU

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DISCLAIMER

I hereby certify that the work in this dissertation is my own except for the quotations and summaries which have been duly acknowledged. I declare that I have no financial interest in the instruments in this study.

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Dr Jasvinjeet Kaur Sidhu

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ABSTRAK

PENGENALAN

Glaukoma adalah penyebab utama kebutaan di seluruh dunia dimana, glaukoma sudut terbuka (POAG) adalah jenis yang utama diikuti oleh glaukoma sudut tertutup (PACG). Pesakit glaukoma mengalami kesukaran untuk melakukan aktiviti harian yang memerlukan penggunaan penglihatan sisi. Ini akan memberi kesan kepada pelbagai aktiviti harian termasuk kebolehan membaca. Walaupun terdapat intervensi perubatan yang berkesan untuk mengurangkan kemerosotan medan penglihatan bagi pesakit glaukoma, namun kehilangan medan penglihatan yang berlaku adalah bersifat kekal.

OBJEKTIF

Untuk menilai prestasi pembacaan antara pesakit glaukoma primer menggunakan bahan bacaan harian serta hubungkait dengan tahap keterukan bidang penglihatan glaukoma.

KAEDAH PENGAJIAN

Satu kajian rentas telah dijalankan melibatkan pesakit glaukoma primer antara Ogos 2020 dan Ogos 2022 di Klinik Glaukoma, Hospital Universiti Sains Malaysia (HUSM). Syarat-syarat kelayanan adalah ketajaman penglihatan binokular ≥ 6/12. Penilaian visual asas termasuk ketajaman penglihatan, ujian medan penglihatan monokular Humphrey visual field (HVF), ujian medan penglihatan binokular Esterman dan kepekaan kontras telah dijalankan. Pesakit glaukoma dibahagikan kepada tiga kumpulan berdasarkan kepada tahap glaukoma mengikut kriteria Hodapp-Anderson-Parish. Pesakit diminta membaca lima bahan bacaan Bahasa Malaysia yang digunakan dalam kehidupan seharian, misalnya

tajuk surat khabar (0.9°), sub-tajuk surat khabar (0.43°), saiz cetakan surat khabar (0.28°), cetakan label farmasi (0.28°) dan, bil (0.14º). Bahan bacaan dipersembahkan 40 cm dari pesakit (jarak bacaan) dan pembacaan dilakukan dalam keamatan cahaya sebanyak 500-600 lux. Prestasi pembacaan dinilai berdasarkan bilangan perkataan yang dibaca dan kesilapan yang dilakukan dalam tempoh membaca selama satu minit. Jam randik digunakan untuk menyukat masa.

KEPUTUSAN

Seramai 132 pesakit yang terdiri daripada 42 pesakit glaukoma ringan, 45 sederhana dan 45 pesakit glaukoma teruk telah direkrut dalam kajian ini. Purata kelajuan membaca menurun dengan meningkatnya tahap glaukoma bagi semua bahan bacaan ($p<0.001$). Terdapat perbezaan dalam kelajuan membaca yang signifikan untuk saiz cetakan surat khabar, cetakan label farmasi dan bil menurut tahap keterukkan bidang penglihatan ($p<0.001$). Pesakit dengan glaukoma tahap teruk mencatatkan lebih banyak kesilapan dalam membaca semua bahan bacaan jika dibandingkan dengan mereka yang mengalami glaukoma ringan dan sederhana. Secara keseluruhan pesakit glaukoma mendokumenkan lebih banyak kesilapan semasa membaca cetakan yang lebih kecil seperti saiz cetakan surat khabar, cetakan label farmasi dan bil. Penemuan ini kekal signifikan apabila faktor seperti umur, komorbiditi, tahap pendidikan dan pekerjaan di analisakan bersama.

KESIMPULAN

Prestasi membaca dalam kalangan pesakit glaukoma tahap teruk adalah rendah jika dibandingkan dengan pesakit glaukoma tahap ringan dan sederhana walaupun, mempunyai ketajaman penglihatan yang baik.

ABSTRACT

INTRODUCTION

Glaucoma is the leading cause of irreversible blindness worldwide with primary open angle glaucoma (POAG) as the predominant subtype followed by primary angle closure glaucoma (PACG). Patients with advancing glaucoma suffer from increasing difficulty with daily living activities that require peripheral vision like reading. While there are effective medical interventions to minimize the progression of peripheral visual field loss in glaucoma, the acquired field loss is irreversible.

OBJECTIVE

To evaluate the reading performances in patients with primary glaucoma according to severity of visual field defect using daily reading materials.

METHODOLOGY

A cross sectional study was conducted involving patients with primary glaucoma between August 2020 and August 2022 at Glaucoma Clinic, Hospital Universiti Sains Malaysia (HUSM). The inclusion criteria include those with good central vision of $\geq 6/12$. Baseline visual acuity, Humphrey visual field (HVF) monocular, binocular Esterman analysis and contrast sensitivity test was conducted. Severity of glaucoma was assessed using modified Hodapp-Anderson-Parish criteria, on the HVF of the better eye. Patients were asked to read five different reading materials, newspaper heading (0.9°), newspaper sub-heading (0.43°), newspaper print size (0.28°), pharmacy label print (0.28°) and bills (0.14°). All reading materials were in Bahasa Malaysia. The reading materials were

presented on a pedestal at a reading distance of 40 cm from the subject, under a fixed light intensity of 500-600 lux. Reading performances were assessed by the number of words read and mistakes made within a minute of reading each material. A stopwatch was used to time the reading.

RESULTS

A total of 132 (42 mild, 45 moderate and 45 severe) patients with primary glaucoma were recruited. The mean reading speed decrease significantly with advancing glaucoma for all reading materials ($p< 0.001$). The difference in reading speed for newspaper print size, pharmacy label print and bill were statistically significant among all three groups of severity ($p<0.001$). Similarly, patients with severe glaucoma documented more mistakes in all five reading materials when compared to those with mild and moderate glaucoma. Patients documented more mistakes when reading smaller prints such as the newspaper print size, pharmacy label print and bill. After controlling confounding factors such as age, systemic comorbidities, education level, and occupation the outcomes were still significant.

CONCLUSION

Reading performance is impaired among patients with severe glaucoma despite a good central vison and visual acuity compared to patients with mild and moderate glaucoma. They read slower with more mistakes.

Chapter 1
Introduction

1.1 Primary Glaucoma

Glaucoma is the leading cause of irreversible blindness nationwide (Zhang N et al., 2021). A total of 3.6 million aged 50 years and above were blind due to glaucoma and it accounts up to 11% of global blindness in 2020 (Sun et al., 2022). Primary glaucoma includes both primary open angle glaucoma (POAG) and primary angle closure glaucoma (PACG) with the later accounting up to 57.5 million people worldwide (Allison et al., 2020). The prevalence of POAG is higher in Asian countries with a prevalence of 2.34% whereas PACG 0.73%. Nevertheless, PACG burden remains highest in East Asia (Wei et al., 2016). Malaysia is a multiracial country. Majority of the population are Malays, followed by Chinese and Indians (Current Population Estimates, Malaysia 2022). Malaysia has a similar demographic and closely related to Singapore. Singapore Malay Eye Study reported that POAG accounted for 69.3% of glaucoma cases and PACG accounted for only 5.3% cases (Shen et al., 2008). It could be postulated that the prevalence of POAG in Malays outweighs that of PACG.

POAG is a chronic, progressive optic neuropathy that is characterised by structural changes in the optic nerve head and/ or with visual field defect without identifiable causes (Asia Pacific Glaucoma guidelines, 2008). Whereas PACG is characterized by an occludable drainage angle and features indicating that trabecular obstruction by the peripheral iris has occurred, such as peripheral anterior synechiae with elevated intraocular pressure and optic neuropathy (Foster et al., 2002).

Glaucoma requires a lifelong follow up and treatment. The aim of treatment is to slow down the disease progression by targeting the single most important modifiable risk factor being the intraocular pressure (Weinreb et al., 2015). Despite on treatment, the disease often continues to progress at different rates giving an impact to the daily activity of patients (Chen PP et al., 2003). The acquired visual field defect is irreversible causing progressive peripheral visual field loss in advancing disease (Weinreb et al., 2015). A study on quality of life in glaucoma patients revealed that many patients with glaucoma undergo anxiety and depression as they are unable to perform their day-to-day activities independently (Wang Y et al., 2017). This indirectly also poses burden on their carer.

Globally there has been an increase in ageing population seen with improvement in healthcare facilities and decline in fertility rates among the population (World Health Organization, 2010). Similarly in Malaysia, the life expectancy has increased significantly over years leading to an aging population. The issue of healthy aging has been an interest in many Asian countries. Healthy aging for glaucoma patients could be achieved by understanding how glaucoma affects patient's reading, a vital daily routine.

1.2 Glaucoma and quality of life

Quality of life (QoL) is defined as individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards, and concerns (Quaranta et al., 2016). It is understood that self-reported quality of life better reflects patients with chronic disease such as glaucoma (Skalicky S E et al., 2016, Spaeth G et al., 2006). Three major categories of patient related outcomes (PROs) questionnaires assess quality of life in glaucoma patients, including those addressing functional status related to vision, overall quality of life and other factors related to disease and treatment (Skalicky S E et al., 2016, Quaranta et al., 2016).

Glaucoma treatment aims to slower the progression of the disease hence preserving visual function and quality of life (Weinreb, Aung & Medeiros., 2014, Quaranta L et al., 2016). Both visual impairment and results of lifelong treatment has a negative impact on patients physical and mental health. Glaucoma patients are burdened by the diagnosis of disease, poor visual acuity, progressive visual field defect, lifelong treatment, and frequent hospital visits (Wu N et al., 2019, Quaranta L et al.,2016, Skalicky S et al.,2013). Even in early disease these patients report poorer quality of life compared to healthy individuals (Dhawan M et al., 2019, Park S et al., 2015). As the disease progress, there is a significant association between physical limitation and poor quality of life. Visual acuity and visual field loss are the key determinants affecting their quality of life (Ramulu PY et al., 2012, McKean C et al., 2007).

A wide range of activities affected include mobility, self-care, driving and reading (Freeman et al., 2008, Ramulu., 2009, Matthews et al., 2015). It is rather pronounced in bilateral compared to unilateral glaucoma (Ramulu., 2009). Glaucoma patients reported fear of falling in advance disease, hence they restrict their physical activity causing decrease quality of life with higher morbidity. Several studies reported, glaucoma patients walked slower, frequently bumped into object and have poor balance. It results in more frequent falls and higher dependency rate. Glaucoma related falls, produces serious fractures in elderly patients (Ramulu PY et al., 2012, Okamoto M et al., 2014, Haymes SA et al., 2007). Glaucoma patients were reported to have difficulty in driving with higher number of accident rates with worsening visual field damage (Montana C & Bhorade A., 2017).

Difficulty with near vision task, especially reading is the most frequent complaint among glaucoma patients. They experience difficulties with smaller prints, poor contrast sensitivity and require a bright surrounding to enhance reading (Burton R et al., 2012). Studies reported that patient with severe disease has slower reading speed with more mistakes. Based on meta-analysis of the effect of glaucoma related vision impairment on QoL using Glaucoma Quality of Life-15 Questionaire (GQL-15), patients with glaucoma showed significantly higher GQL-15 summary scores (SMD = 0.94, 95% CI=0.73 to 1.16) compared to control participants (Wang et al., 2017). Patients with glaucoma were reported to have more anxiety and depression in comparison with healthy individuals (Zhang X et al., 2017).

1.3 Aging process and reading

Reading is defined as the process of extracting and constructing meaning through interaction and involvement with written language (Reading study group., 2002). Cognitive factors that affect reading includes background knowledge, good vocabulary, fluency, and critical thinking (Kiew S and Shah PM., 2020, Smith R et al., 2021). Reading has a great impact on quality of life throughout all ages. Reading varies among different age groups. In a survey done, an average adult above 65 years of age reads approximately 1 hour and 47 minutes in a day (American Time Use Survey., 2016). Older individuals have higher tendency to read from printed reading materials in comparison to reading online by younger adults (Chen SY., 2008). The psychological disposition of technophobia is a common and salient phenomenon among the senior population (Hou J et al., 2017).

Reading in older population is affected by several factors such as font type, font size, contrast, crowding and age (Chen AH et al., 2019, Kaspar K et al., 2015, Calabrese A et al., 2016). Aging leads to difficulty with fine print reading, poor extraction of information from text, reduced contrast sensitivity because of reduced spatial frequency (Seferlis F et al., 2015). Physiological changes such as reduced in accommodation and cataractous crystalline lens leads to reduce quality of near reading (Gupta N et al., 2009). Reading performances in elderly is influenced by both visual and non-visual factors (Gupta N et al., 2009, Chen AH et al, 2019). Visual performances in elderly have been measured based on visual acuity and reading speed in many studies. Standardized reading charts has gained much acceptance. Reading acuity and speed declines in the elderly population (Liu R et al., 2017, McGowan VA et al., 2014). Factors contributing include reduced

contrast sensitivity, deterioration in motor processing such as eye movement and defective transient system (Chen AH et al., 2019, Kliegl R et al., 2004). There is a significant age-related change in crowding zone and shrinkage of visual span that explains reduce in reading speed among the elderly (Liu R et al., 2017). Most of the glaucoma patients are in the elderly group, hence the effects of reading impairments could be a combination of aging and visual field defect from the disease itself.

1.4 Reading in glaucoma patients

Reading is a pleasure and essential to our everyday life. Aspinall et al reported that problems associated with reading is one of the main causes of anxiety among glaucoma patients (Aspinall PA et al., 2008). Reading performance can be quantified through questionnaires and reading function test. Questionnaires are subjective and addresses patient's perspective on reading. Whereas, reading function test is a more objective assessment. Several reading function tests includes, Bailey-Lovie Near Reading Card, Minnesota Low-Vision Reading Test (MNREAD), International Reading Test (IReST), and Rapid Serial Visual Presentation (RSVP) and these has gained much popularity.

Questionnaire based studies reported that glaucoma patients have difficulties with reading, following lines of text and other near vision task (Nelson P et al., 1999, Viswanathan AC et al., 1999, Freeman EE et al., 2008). Reading performance is influenced by a good visual acuity and visual field. These often is impaired among glaucoma patients. Despite a good central vision, glaucoma patients were reported to have slower reading speed, saccade rate, and more reading mistakes due to shrinking

visual field (Ramalu et al., 2009, Kwon et al., 2017). This is especially pronounced among those with moderate to severe glaucoma (Ikeda MC et al., 2021).

Studies using spectral-domain optical coherence tomography (SD-OCT) have demonstrated even early glaucomatous injury involves the macula. Such damage includes loss of retinal ganglion cells and significant shrinkage of dendritic structures and cell bodies of remaining cells in the macula (Hood DC et al., 2012, Hood DC et al., 2013). Disruption of the magnocellular pathway of retinal ganglion cells eventually causes reduced perceptual span, increase saccadic frequency and fixation instability that impair reading speed among glaucoma subjects (Rolle et al., 2019). Previous studies also have shown that deficiencies of letter recognition such as acuity limit or loss of contrast sensitivity led to a significant reduction in reading speed (Legge GE et al., 2011, Kwon M et al., 2012). Reading in glaucoma patients are affected by contrast sensitivity, illumination, print size, and visual span.

1.5 Factors affecting reading in glaucoma

1.5.1 Contrast sensitivity

Contrast sensitivity refers to the difference in luminance or shading that makes an object distinguishable from its background (Kaur K & Gurnani B., 2020). It is the second most important predictor of functional vision after visual acuity. Contrast sensitivity depends on complex interaction of the neural mechanism of the eye. Multiple tools are available to measure contrast sensitivity, which includes the Pelli Robson chart, Regan chart, and Arden grating. Pelli Robson chart is the most widely used method, as it permits direct visualization of changes in contrast sensitivity. It is measured based on logarithmic scale.

Many ocular diseases are affected by contrast sensitivity, likewise in glaucoma. It is suggested that contrast sensitivity is an early marker to detect glaucomatous changes (Ichhpujani P et al., 2019). Studies have reported that decrease in contrast sensitivity is due to reduction in retinal ganglion cells in glaucomatous eyes. In contrary to visual acuity that is preserved till advance glaucoma, changes in contrast sensitivity occurs early and provide valuable insight how glaucoma patients function in their daily lives (Richman J et al., 2010). Decrease in contrast sensitivity can be more physiologically disturbing compared to loss of visual acuity (Kaur K & Gurnani B., 2020).

Multiple studies reported that contrast sensitivity declines with severity in glaucoma. Patients reported poor quality of reading, with modestly slower reading speed (Ramulu PY et al., 2013). Reading speed markedly reduced in glaucoma patients presented with lower contrast between text and as compared to their healthy counterparts (Burton et al., 2012). There was a strong correlation ($p<0.001$) between binocular contrast sensitivity

and total Assessment of Disability Related to Vision (ADREV) score. For every decrease of contrast sensitivity by 0.15 points on Pelli-Robson Chart, the ADREV score decreased by 9% (Richman et al., 2010).

1.5.2 Illumination

Lumens is the unit of measurement to quantify the amount of visible light the human eye can see. Illuminance is the metric used to measure the light intensity within a space. It is measured in terms of lumens per square meter (lux) (Enoch J et al., 2019). The common illuminance level ranges from 10,000 lux in a full day light to 300-500 lux in a office light and dimmer in a twilight of 10 lux. Illumination could be measured using a standard lux meter. Normal reading is affected by illumination, with a recommended illumination of 300-500 lux for a good quality reading. Studies show that reading speed of smaller letters improves with increase light level from mesopic to photopic (Seiple W et al., 2018). Several studies have reported a strong association between increase illumination and improve reading performances among healthy individuals and patients with low vision (Ram & Bhardwaj et al., 2017, Seiple W et al., 2018, Bowers et al., 2001).

Photophobia and glare are a common problem faced by glaucoma patients especially in advance glaucoma cases (Enoch J et al., 2020). Glaucoma patients often report complaints under extreme (low, high or changing) luminance conditions. (Hu CX et al., 2014). Ronald et al, reported that low luminance condition discriminates best between glaucoma and controls and complaints increase with disease severity. For a good quality reading among glaucoma patients, light levels with uniform and increasing illumination provides better vision quality.

Performance based studies using the ADREV, a nine-task performance-based measure which includes one task of reading in reduced illumination, showed that reading in reduced illumination was similarly difficult to a test of locating objects (Enoch J et al., 2019). A strong correlation was reported between reading in dim light with contrast sensitivity, visual acuity of the worse eye and binocular visual acuity ($r = 0.68$, -0.69, and -0.67 respectively, all $P < 0.01$) (Altangerel U et al., 2006).

1.5.3 Print size

Print size is an important aspect of reading. Critical print size is the smallest character size for which reading is possible at maximum speed (Gordon et al, 2011). Increase in print size has no doubt increase the reading speed in normal individuals, this is especially true for older individuals. The Salisbury Eye Evaluation Project reported increase in reading speed in larger print sizes in unilateral and bilateral glaucoma patients. In a questionnaire-based study, reading small print was reported as a task that caused great difficulty for glaucoma patients (Altangerel et al., 2006). Several reading charts has been used to assess the correlation between reading speed and print size. Reading speed increase with size of font size (Ishii et al., 2013, Teresa et al., 2019). Nevertheless, a recent study reported that there is no correlation between reading speed and line spacing or font size among glaucoma patients (Ikeda MC et al., 2021). Till date there is no exact conclusion regarding the critical print size that fits all patients.

1.5.4 Shrinking visual span

Visual span is defined as a small window for reliable letter recognition in the visual field. It has been reported in several studies regarding the strong correlation between visual span and reading speed among normal individuals (Legge et al., 2001, Legge et al., 2007, Yu et al., 2010). Kwon et al reported that 34-52% of reading speed variability can be accounted for by the size of visual span. The size of visual span was the only contributor to reading speed in glaucoma patients when other reading components were held constant (Kwon MY et al., 2017). A larger visual span results in a smaller number of fixations and saccades to read, thus increase the speed of reading (He Y et al., 2013).

1.6 Rationale of study

Glaucoma will be a major health problem as Malaysia is moving towards an aging country soon. As a major cause of vision loss, glaucoma can affect a broad array of activities in the long run. Reading is one of the domains which is mostly affected in primary glaucoma patients based on QoL questionnaires. Reading is an important aspect of daily life as we often need to read to carry out daily activities, besides its one of the few pleasures of life. Reading impairments faced by glaucoma patients, may prevent them from reading thus being more dependent to their care givers besides having a psychosocial impact on their daily lives. Many glaucoma patients have anxiety and subsequently lead to depression.

These limitations could be overcome by objectively assessing the reading performances of glaucoma patients. QoL assessment using questionnaire is subjected to various biases especially in terms of psychological influence, recall bias and the impact of physiological aging process. Thus, this performance-based study may provide an objective understanding of the reading impairments among patients with glaucoma. The outcome of this study may provide an important reference for development of visual rehabilitation module for patient with glaucoma in the future.

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Chapter 2

Objective

2.0 STUDY OBJECTIVES

2.1 GENERAL OBJECTIVE

1. To evaluate the reading performances in patients with primary glaucoma according to severity of visual field defect using daily reading materials.

2.2 SPECIFIC OBJECTIVES

1. To compare the reading speed according to the severity of visual field defect in patients with primary glaucoma.
2. To compare the reading mistakes according to the severity of visual field defect in patients with primary glaucoma.