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Contrast Sensitivity and Reaction Time in Cataract Patients: A Comparative Analysis of Pre and Post Cataract Surgery

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ABSTRACT: The purpose of this study was to measure and compare pre and post-operative Contrast sensitivity (CS) and Reaction Times (RTs) in cataract patients. CS provides valuable information on visual function, independent of visual acuity (VA). It represents the ability of the eye to detect a slight difference in luminance of two regions without distinct contours. This visual function or ability is affected by various disease conditions of the eye including cataract. Measurement of visual function can be reliable and useful for detection, screening and evaluation of a variety of diseases such as cataract. In this research work, 14 cataract patients comprised both males and females, between the ages of 50 to 75 years, with no other ocular diseases were used. The research was carried out at Stella Obasanjo Hospital, Benin City, Edo State, Nigeria, where the patients were also recruited. In each subject, a computer based test was used to measure reaction times (RTs) over a wide range of contrast levels *two days* before and nineteen days after cataract surgery. Mean values of CS for the operated eyes (OE) was 0.84 log unit, and 0.60 log unit for the non-operated (NOE). Mean values of RTs for OE was 3801.32±0.22ms and 3598.37±0.31ms for NOE. Statistical analysis was carried out to examine the significant difference between the pre- and post operative CS/RT The result of the research showed that there was significant difference between CS and RT before and after cataract extraction, with marked improvement in Cs and RTs obtained post-operatively.

Keywords: Contrast sensitivity, Reaction time, Cataract surgery, Computer monitor

Introduction

Conventionally, the standard and most routine test of visual function in cataract patients is visual acuity (VA). However, some patients present with complain of poor vision despite relatively good VA (Koch 1989; Stifter *et al.,* 2006). In these patients, evaluation of other tests of visual function such as contrast sensitivity (CS) is necessary (Adamsons *et al.,* 1992). CS is the ability of the eye to detect a slight difference in luminance of region without distinct contours (Choudhry *et al.,* 2002). Therefore, it can be used to evaluate the degree to which this ability has been lost. It reveals a handful of subtle levels of vision not detectable by routine visual acuity test. Thus it provides a more accurate assessment or follow-up of the progress of cataract (David 2006). CS is more related to the real world than VA in patients with cataract.

Low contrast sensitivity can be a symptom of certain conditions or diseases such as cataract, etc. Cataracts are thought to increase intraocular light scatter, which can decrease retinal image contrast and adversely affect contrast sensitivity (American Academy of Ophthalmology, 1990). Measurement of CS can be useful for detection, screening and evaluation of a variety of diseases such as cataract (Friston *et al*., 2000).

Reaction time (RT) is the interval between the time of onset of a stimulus and the time taken to correctly respond to the stimulus. RT exhibit simple relationship with contrast or CS (Holmes *et al.,* 2000). The receipt of information (visual in this case), its processing, decision making and giving the response or execution of the motor act are the processes which follow one another and make what is called the reaction time. Reaction time is important for our everyday lives and needs intact sensory system, cognitive processing, and motor performance. Many factors have been shown to affect visual reaction times and these include age, distractions, limb used for test (Grrishma *et al*., 2014), various disease conditions of the eye like cataract, glaucoma, macular degeneration, diabetic retinopathy etc.

Karen et al., 2000 found a systematic slowing of reaction time (i.e. increase in reaction time) for detection as target contrast was reduced. Similarly, studies with grating stimuli revealed that reaction times decrease with increasing contrast (Harwerth & Levi, 1978; Lupp *et al*., 1976; Mihaylova *et al.*, 1999). Visual perception, therefore, becomes faster (shorter reaction times) with increasing contrast.

The crystalline lens of the eye along with the cornea helps to refract light to be focused on the retina. This is possible as the crystalline lens is a transparent structure. Normally, all the layers of the lens are clear, and light passes through it unobstructed. However, with age or due to other factors the crystalline lens material can become cloudy, yellowish, brownish, and even opaque (thereby losing its transparency) (Ted, 1998). This loss of transparency or opacification of the crystalline lens describes cataract.

A cataract as defined by Khurana (2012) is any opacity or cloudiness in the natural crystalline lens of the eye. The term cataract is used loosely to mean the occurrence of a discontinuity of the lens in such magnitude as to cause a noticeable dispersion of light. The crystalline lens of the eye, where cataracts form, focuses light that passes into the eye, producing clear, sharp images on the retina. However, as one ages, senile changes cause tissues within the lens to break down and clump together, clouding small area within the lens, and the clouding develops with time, becoming denser and involving a greater part of the lens. This opacity or clouding of the lens scatters light as it passes through the lens, preventing a sharply defined image from reaching the retina and as a result vision becomes blurred.

To further polish the concept of light scattering effect of cataract, American Academy of Ophthalmology, 1990, stated that cataracts are thought to increase intraocular light scatter, which can decrease retinal image contrast and adversely affect contrast sensitivity which is affected according to (Stifter *et al*, 2006) far more than visual acuity in patients with cataracts.

According to Owsley (2003), contrast sensitivity is a measure of the visual ability to see objects that may not be outlined clearly or that do not stand out from their background and so tells us how much contrast a person requires to identify objects from their background especially when the visual targets are at low contrast. It represents the ability to perceive slight changes in luminance between regions which are not separated by definite borders (Khurana and Khurana, 2009). Furthermore, these authors were of the opinion that in many disease conditions, loss of contrast sensitivity is more important and disturbing to the patient than the loss of visual acuity. This should be expected as it agrees with the argument of Ventruba, 2005, that CS is more related to the real world than VA in patients with cataract.

Low contrast sensitivity score can be a symptom of certain eye diseases such as cataract, glaucoma, macular degeneration etc. Therefore, CS testing can help in the detection and evaluation of these eye problems especially cataract. It thus provides valuable information on visual function, independent of visual acuity (Haegerstrom, 2005).

Impairment in real-world visual performance is better predicted by a CS test than by high contrast VA (David 2006, Wood et al., 2005). Measurement of VA alone is insufficient for the evaluation of visual complaints in cataract patients, it was then suggested that examination simulating everyday visual situations such as CS measurement in conjunction with a glare source may be greatly useful (Javad *et al.*, 2011). After cataract surgery and lens implantation there was highly significant improvement in binocular CS (Skorkovska, *et al.* 2001; Ventruba, 2005,).

The aim of this study is to compare preoperative and postoperative contrast sensitivity and reaction times in patients with cataracts. We hypothesize that there is significant difference in threshold contrast sensitivity and corresponding mean reaction times before and after cataract extraction in patients with cataract. Hopefully, this study will provide support to the necessity of routine evaluation of CS especially on patients with cataract

Materials and Methods

Research design: This is a prospective experimental research study, which was carried out at Stella Obansanjo Hospital, Benin City, Edo State. The pre-test was carried out on each subject every Monday, two (2) days before the cataract surgery, which was usually performed on Wednesdays at the Stella Obansanjo Hospital. The post-test was carried out on each subject nineteen days after the surgery. The pre and post-tests lasted for a period spanning from

June twenty-ninth (29th) through August-tenth (10th) for the pre-tests and July twentieth (20th) through September seventh (7th), for the post tests.

Study population: Fourteen subjects were used for this study. A total of nineteen subjects underwent the pre-operative test. Four out of these subjects did not return for the post-operative test. One id not afterward undergo the surgery. This brought the number of subject successfully tested pre and post operatively to fourteen. The subjects were both males and females aged 50 – 75 years. Convenient sampling technique was used for selecting the subjects. Patients that were booked for cataract surgery in the hospital were used.

Ethical clearance was obtained from Hospital Management Board (HMB), Benin City, Edo State. Written permission to carry out the research study was thereafter granted by the Hospital Management.

Informed consent was obtained from each participant in the research in accordance with the medical association declaration of Helsinki.

Exclusion criteria are subjects; with other ocular conditions/disease, without cataract, with post surgical complications, with systemic diseases such as diabetes mellitus or hypertension.

Description of procedure: The participants for the study were from Stella Obansajo Hospital. They were between 50 – 75 years of age. A total of nineteen subjects were tested pre-surgically but only fourteen were successfully tested pre and post-surgically making the number of subject used for the study fourteen.

Contrast sensitivity and reaction times were measured two (2) days before and nineteen days (2 weeks and five days) after the cataract surgery. A computer software/program (Contrast Sensitivity Test Suite (CSSUITE), version 0.93) was used to measure each subject's reaction times (in milliseconds {ms}) to a wide range of contrast.

Contrast sensitivity and reaction times were measured for each subject using the computer-based contrast sensitivity test program, detailed procedure as in Bailey et al 2003.

Each subject was comfortably seated in a uniformly lit room. The laptop was positioned at half a meter distance (50cm) away and in front of the subject.

The computer program randomly generated in succession, stimuli or targets consisting of blinking squares of equal sizes with varying contrast levels (in log units) ranging from 0.0 to 2.3 log units, in one of four quadrants on the computer display screen. Forty-eight stimuli (two of which represent each contrast level) corresponding to the twenty-four contrast levels were presented per session of the test. The duration of each stimulus was 6000 milliseconds (ms).

Trial tests were carried out in order to enable participants adapt to the test and prevent delays in reaction time due to unfamiliarity with controls. A single warning tone indicated commencement of the test and participants were expected to touch the target presented on the computer screen as soon as it appeared. The target correctly located by the subject was clicked on by the examiner. The program calculated the reaction times (in milliseconds {ms}) between the target presentation and target identification by the participant. The test was done monocularly on the cataractous eye before the surgery and after the surgery the test was repeated for the operated eye, the fellow (non-operated eye) and binocularly for both the operated and fellow eye. The computer automatically generated results at the end of the test indicating contrast levels and corresponding reaction times. Reaction times were the average values (in milliseconds) of two responses and if the subject did not respond within 6000ms, the reaction time read 'NEVER' instead of a number which means there was no time earned at that contrast level and the next target was presented.

Statistical analysis: Student t-test, was used to analyze the result. Tables and graphs were used to present data.

Results

Results are presented in tables and graphs as shown below. Tables 1 and 2 showed that the mean difference between the CS before and after cataract surgery in operated eyes = -0.37$\pm$0.14log unit. T-test gave a tabulated t-value of -9.67 which was greater than the critical t-values both at 0.05 level of significance ($t_{0.05(2).13}$:2.160; ($P < 0.05$)) and 0.01 level of significance ($t_{tab0.01(2).13}$:3.012; ($P < 0.01$)). For RTs, mean difference = -662.35ms. Similarly, t-calculated (-19.59) was greater than t-critical at both levels of significance.

Figure 1 reveals that the reaction times before cataract surgery at the different log contrast sensitivity levels are higher than reaction times after cataract surgery. The threshold contrast sensitivity before the surgery was 0.8 this increased to 1.4 after surgery, while the reaction times were 4.5 and 5 milliseconds respectively. The CS was about doubled while the RT increased only by 11.1%.

Mean values of CS for the operated eyes (OE) was 0.84 log unit, and 0.60 log unit for the non-operated (NOE). Mean values of RTs for OE was 3801.32±0.22ms and 3598.37±0.31ms for NOE. t-calculated for CS & RTs were 2.3021 ($t_{cal.}>t_{tab0.05(2).13}$ {P<0.05}) and 0.552 ($t_{cal}<t_{tab0.05(2).13}$ {P>0.05}) respectively (Tables 3 and 4).
Comparison of CS and RTs results for both eyes (BE) and the operated eyes (OE) post-operatively we got for CS mean values of 0.84 log unit (BE) & 0.91log unit (OE) and for RTs mean values of 3801.32±0.06 and 3002.80±0.06ms for BE and OE respectively. t-calculated for CS & RTs were 0.8461 ($t_{cal.}<t_{tab0.05(2).13}$ {P > 0.05}) and 0.8982 ($t_{cal}<t_{tab0.05(2).13}$ {P>0.05}) respectively, t-tabulated being 2.160 (tables 5 and 6).It can be seen from the graph in figure 2 that the reaction times before cataract surgery at the different log contrast sensitivity levels are higher than reaction times after cataract surgery. It is also obvious from the graph that there is no significant difference in reaction time obtained post-operatively in the operated eyes and in both eyes (binocularly). Similarly, there is no significant difference in RTs between operated and fellow eyes as can be seen in the graph.

Table 1: Comparison of Contrast Sensitivities before and after cataract surgery in operated eyes using T-test.
T-test: One Sample Two Tailed Hypothesis

Statistics		
Mean:	-0.3714	
Standard Deviation:	0.1437	
Standard Error of Mean:	0.0384	
Df	13	
Confidence Interval (C.I.) @ 95%:	-0.3714 ± 0.0829	
Calculated t:	-9.6694	$t_{cal}< t_{tab}$:
Critical t ($t_{(0.05l)(2).13}$):	2.160	P < 0.05
Critical t ($t_{(0.01)/2).13)}$):	3.012	P < 0.01

P. value: 0.000000358

From the table above $t_{(calculated)}>t_{(critical)}$ both at 0.05 and 0.01 levels of significance (P < 0.05 and P < 0.01). This shows that there were significant differences between the contrast sensitivities before and after cataract extraction (P < 0.05).

Table 2: Comparison of Reaction Times to Contrast Sensitivities before and after cataract surgery in operated eyes using T-test.
T-test: One Sample Two Tailed Hypothesis

Statistics		
Mean:	-662.348ms 126.513ms	
Standard Deviation:	33.809	
Standard Error of Mean:	13	
Df	-662.348± 73.027	
Confidence Interval (C.I.) @ 95%:	-19.591	
Calculated t:	2.160	$t_{cal}< t_{tab}$:
Critical t ($t_{(0.05l)(2).13}$):	3.012	P < 0.05
Critical t ($t_{(0.01)/2).13)}$):		P < 0.01

P. value: 0.000161
From the table above $t_{(calculated)}>t_{(critical)}$ both at 0.05 and 0.01 levels of significance (P < 0.05 and P < 0.01). This shows significant difference in the reaction times to decreasing visual stimulus contrast before and after cataract extraction are.

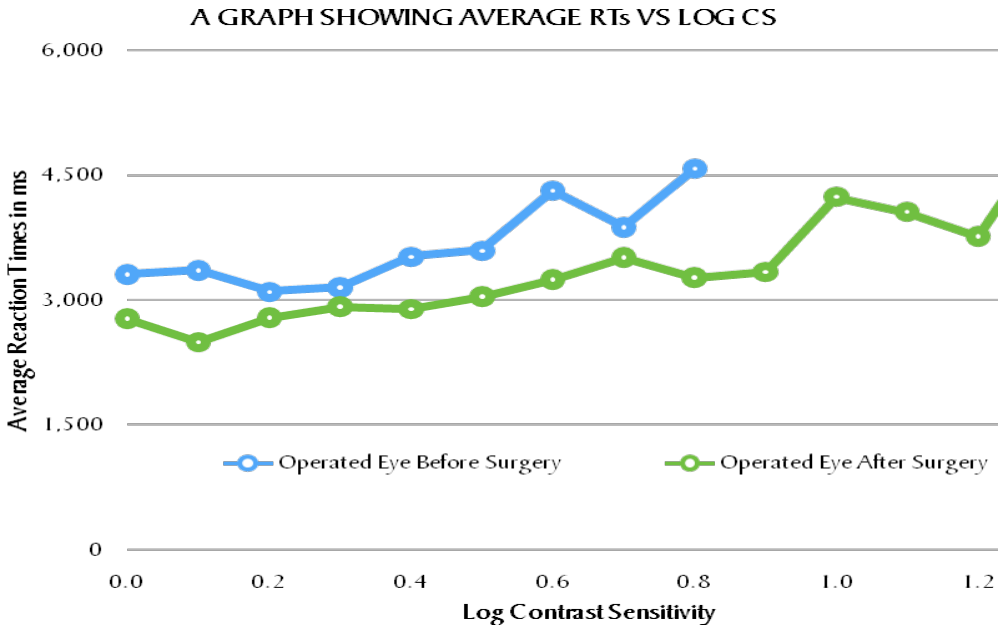

Fig 1: A graph showing average reaction times before and after cataract extraction.

From the graph it can be seen that the reaction times before cataract surgery at the different log contrast sensitivity levels are higher than reaction times after cataract surgery.

Table 3: Comparison of post-operative contrast sensitivity (CS) in operated eye (OE) and binocular CS {OE & non-OE)

Statistics	**Post-Operative threshold log cs (n_1)**	**Post-Operative Binocular threshold log cs (n_2)**
N	14	14
Mean (N)	0.836	0.907
Standard Error of Mean (SEM)	0.0599	0.0588
Standard Deviation (S)	0.2240	0.2200
Variance (S^2)	0.05	0.0484
Pooled Variance	0.049284615	
DF	13	13
Calculated T	0.8461	
Critical T ($T_{(0.05L)(2).13}$):	2.160 P > 0.05	

P. value: 0.402399

$t_{(calculated)} < t_{(critical)}$ which implies that P > 0.05. CS in the operated eyes and binocular CS are not significantly different.

Table 4: Comparison of post operative contrast sensitivity (CS) in operated eye (OE) and fellow non-operated eye

Statistics	**Post-Operative Threshold Log CS (N_1)**	**Log CS in Fellow (Non-operated) Eye (N_2)**
Observation	14	14
Df	13	13
Mean (N)	0.836	0.600
Standard Error of Mean (SEM)	0.0599	0.0588
Standard Deviation (S)	0.2240	0.3113
Variance (S^2)	0.05	0.097
Pooled Variance	0.073542307	
Calculated t	2.3021	
Critical t ($t_{(0.05l)(2).13}$):	2.160 P < 0.05	

P. value: 0.02975

$t_{(calculated)} > t_{(critical)}$ which implies that P < 0.05. Null hypothesis H_O is therefore rejected and alternate hypothesis H_A accepted. CS in the operated eyes and fellow (non-operated) eyes are significantly different.

Table 5: Comparison of Post-Operative Reaction Times to Contrast Sensitivities in Operated Eyes and Fellow (Non-operated) eyes using T-test
T-test: Two Sample; Two Tailed Hypothesis

Statistics	**Post-Operative RTS in OE**	**RTS in Fellow (Non-Operative) Eye**
Observation	14	14
Df	13	13
Mean (N)	3801.323	3598.369
Standard Error of Mean (SEM)	254.6735474	265.2004065
Standard Deviation (S)	952.90116	992.28906
Variance (S^2)	908020.6238	984637.5777
Pooled Variance	946329.1008	
Calculated t	0.552	
Critical t ($t_{(0.05l)(2).13}$):	2.160 P > 0.05	

P. value: 0.5856

$t_{(calculated)} < t_{(critical)}$ which implies that P > 0.05. Null hypothesis H_O is therefore accepted. No statistically significant difference was found in the reaction times between operated and fellow (non-operated) eyes.

Table 6: Comparison of Post-Operative Reaction Times to contrast Sensitivities in Operated Eyes (OE) and Binocular CS {OE & non-OE) using T-test
T-test: Two Sample; Two Tailed Hypothesis

Statistics	**Post-Operative RTs in OE**	**Binocualr RTs**
Observation	14	14
Df	13	13
Mean (N)	3801.323	3002.8
Standard Error of Mean (SEM)	254.6735474	851.7199013
Standard Deviation (S)	952.90116	3186.84406
Variance (S^2)	908020.6238	10155975.05
Pooled Variance	5531997.839	
Calculated t	0.8982	
Critical t ($t_{(0.05l)(2).13}$):	2.160 P > 0.05	

$t_{(calculated)} < t_{(critical)}$ which implies that P > 0.05. Null hypothesis H_O is therefore accepted. No statistically significant difference in reaction times is found post-operatively between operated and both (operated and non-operated) eyes.

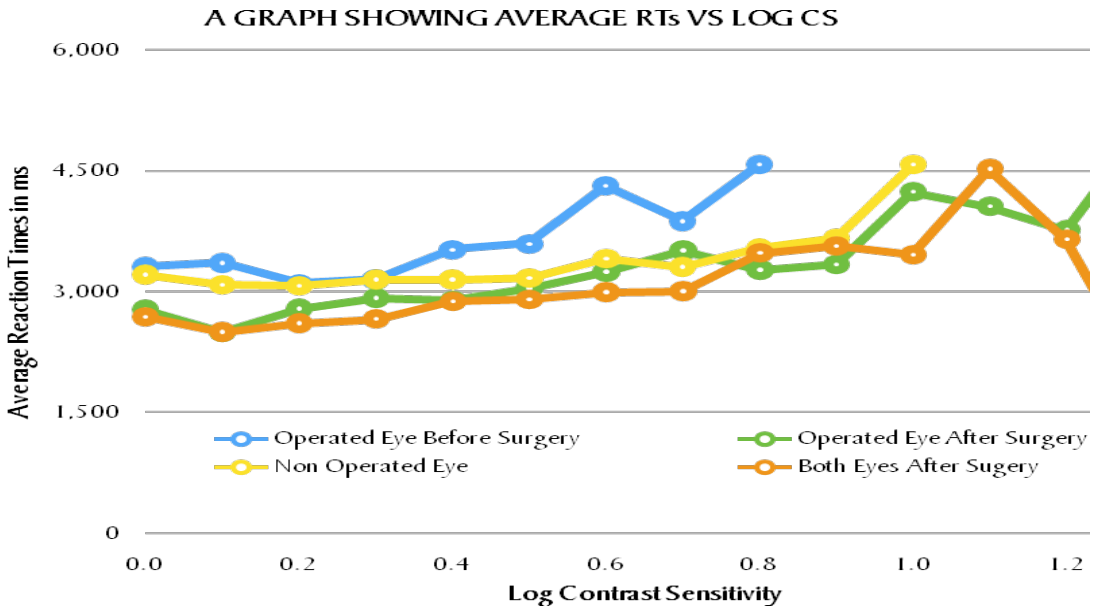

Fig. 2: A Graph Showing Mean RTs vs Log CS for Operated Eyes (before and after surgery), fellow non-operated) Eyes and Both (Operated and Non-operated) Eyes

It can be seen from the graph that the reaction times before cataract surgery at the different log contrast sensitivity levels are higher than reaction times after cataract surgery. It is also obvious from the graph that there is no significant difference in reaction time obtained post-operatively in the operated eyes and in both eyes (binocularly). Similarly the slight difference in RTs between operated and fellow eyes as can be seen in the graph is not statistically significant.

Discussion

Reaction times to varying contrast levels were measured on each subject using the contrast sensitivity test suite (CSSUITE), a computer based programs. Pre and post-operative CS and RTs results were obtained for the operated eyes. CS and RTs were also measured and results obtained for the fellow (non-operated) eyes as well as binocularly for both the operated and non-operated eyes. Comparing post-operative CS for the operated eyes, t-calculated (-9.6694) is significantly greater than t-tabulated, ($t_{0.05(2).13}$:2.160), both at 0.05 and 0.01 levels of significance ($P < 0.05$ and $P < 0.01$). There were significant differences between contrast sensitivity before and after cataract extraction, with marked improvement obtained post-operatively. This is therefore statistical evidence to accept the alternate and reject the null hypotheses of no difference. As stated by American Academy of Ophthalmology, 1990), cataract decreases retinal image contrast by light scatter thereby causing a reduction in contrast sensitivity. Our findings agreed with that of Skorkovska, *et al*., 2001, and Ventruba, 2005, which stated that after cataract surgery and lens implantation there was highly significant improvement in binocular CS.

For Reaction Time, t-calculated (-19.591) is also greater than t-tabulated ($t_{0.05(2).13}$:2.160) at both 0.05 and 0.01 levels of significance. There was reduction in reaction times after cataract extraction. This is clearly shown graphically as can be seen in figure 1. Reaction time to visual stimulus is partly dependent on contrast sensitivity. This agrees with the findings of Karen *et al*, 2000, when they measured RTs in patients with and without simulated cataract and found that with simulated cataract, CS was reduced and reaction times were slowed correspondingly. Our findings also agrees with other, studies with grating stimuli which revealed that reaction times decrease with increasing contrast (Harwerth and Levi, 1978; Lupp *et al*., 1976, Mihaylova *et al*., 1999). No difference was found in both CS and RTs between the operated eyes and binocularly.

Based on the findings from this research work we concluded that cataract causes a reduction in contrast sensitivity and an increase in reaction time and that removal of cataract remarkably improves both contrast sensitivity and reaction time.

Based on the findings from the research work the following are recommended:

1. It is highly recommended that measurement of contrast sensitivity especially in cataract patients should be routinely practice in clinics.
2. Contrast sensitivity test should be included in the test for follow up in cataract surgery.

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