



Original Article

Comparison of Duo-Chrome Test Performed in Astigmatic Patients before and after Cylindrical Correction

A Authors

Maria Hussain¹Ayesha Saleem²Rafia Roohi³Tayyaba Bashir⁴Zoya Hussain⁵

For Authors' Affiliation See Last Page of Article

Correspondence Author:

Ayesha Saleem

Optometrist,

College of Ophthalmology &

Allied Vision Sciences (COAVS), Lahore.

Purpose: The main objective of this study is to compare the results of duo-chrome test performed in astigmatic patients before and after cylindrical correction.

Material and Methods: A quasi experimental study was conducted on 42 patients having astigmatic refractive error. People aged 15-58 years were included in this study. The study group was taken without discrimination of gender and excluding those who were mentally retarded, who had other pathological disorders of the eye, uncooperative patients, those who were not willing to share their data. Data was collected on self-designed proforma after taking consent from patient. V.A of all astigmatic patients was assessed on log MAR visual acuity chart at 4m. Trial lenses and duo-chrome test screen was used.

Results: The mean value for difference in spherical component of right eyes after duo-chrome results was 0.61 ± 0.34 (SE=0.05) and for the duo chrome results performed after cylindrical correction was 0.56 ± 0.29 (SE=0.04). And in left eyes the mean value for difference in duo-chrome results before performing cylindrical correction was 0.53 ± 0.36 (SE=0.05) and that performed afterwards was 0.50 ± 0.31 (SE=0.04), p-values with paired sample t-test is 0.22 for right eyes and 0.45 for left eyes of the patients, which shows that duo-chrome test results before and after cylindrical correction show no significant difference.

Conclusion: It is concluded from this study that there is insignificant difference between the results of duo-chrome test before and after cylindrical correction. Hence, duo-chrome test is equally useful to be performed before and after correcting cylindrical component during refraction.

Introduction:

Visual acuity is the ability of eye to see focused image of an object at a particular distance and determination of focal condition of eye, and its correction by optical devices is refraction. An eye without any refractive error i.e. normal is said to be emmetropic, while the one which is unable to see clear image is said to be ametropic. Myopia, hyperopia and astigmatism are the main types of refractive error. Duo-chrome test (also called as bi-chrome test) is a post refraction test that is used to refine the end point of refraction. For more than 60 years it is suggested by textbooks to use the duo-chrome test clinically for verification of the final refraction.¹ Duo-chrome test was designed by Pech in 1933 while some authors say it was tested as early as 1927 by Clifford Brown.² Since its introduction the red-green duo-chrome test has become a popular clinical tool.³ The red-green duo-chrome test can also be used in research protocols to prevent over or under correction for distance⁴ and to provide final refraction,⁵ when a variance exists between other methods.⁶

A spherical optical system focuses a single source object on a single point on retina, unlike spherical refractive error in astigmatism the rays of light entering the eye cannot converge to a point focus but form focal lines hence eye has different refractive power in different meridians i.e. it doesn't focus light on a single point rather light is focused at two different points having different distances from retina forming point of max focal power and min focal power, the distance between these points is called as 'Conoid of Sturm'. If these two points have same distance from retina a circular blur image of point source is formed and this circle is said as circle of least confusion. In astigmatism mainly cylindrical correction is required to be given.

Duo-chrome test makes use of chromatic aberration of eye.⁷ Tests that make use of chromatic aberration of eye are sensitive detectors for spherical and cylindrical refractive errors. They have become quite practical for finding out final spherical refraction as red-green or duo-chrome test, but for astigmatism they are not often used, though described and recommended.⁸

It is justified that normal human eye i.e. without any refractive error is emmetropic for yellow light, hyperopic for green and myopic for red.⁹ According to chromatic aberration longer (red) wavelengths are refracted less than the shorter (green) wavelengths, red and green wavelengths have same dioptric distance 0.25 D from yellow wavelength (570 nm).

The duo-chrome test involves the projection of black letters or symbols onto an equally divided green (at approx 535 nm) and red (at approx 620 nm) background.¹⁰ While using duo-chrome patient is said to look at the screen and tell on which side he sees the letter more clearly "red side" or "green side". The green wavelengths are focused in front of retina and red are focused behind it. So, in emmetropic eye i.e. in which

the light from infinity is focusing directly on retina letters from both red and green sides are equally clear. In myopia, light rays focus in front of retina so letters with red background appear sharper indicating an overcorrection of refraction (add minus power). In hyperopia, since light rays focus behind the retina letters on the green side appear to be more sharp which indicates under correction of refraction (add plus power). If letters on both sides appear equally clear that means neutrality is reached. Duo-chrome test is a subjective test that demands response from the patient and is used to refine the spherical endpoint. Red-green duo-chrome test is also applicable to persons having color vision defect.¹¹

In astigmatic refraction Jackson Cross Cylinder (JCC) is used to refine the power and axis of cylindrical lens. The JCC is a lens made up of a pair of cylinders having equal power, one convex and one concave, with their axes 90 degrees to each other.¹² For correction of power JCC is placed in front of the eye in one position, conoid of Sturm collapses and vision is improved which means additional correcting cylinder is needed, in position two conoid of Sturm expands and vision gets worse so it is indicated that less cylindrical power is needed. The placement of conoid of Sturm and COLC changes with accommodation. As said by Loo and Jacobs¹³ the accuracy of the spherical refraction does not produce any prominent change in the precision of JCC axis determination, irrespective of whether the patient had up to 0.75D of myopia or hyperopia. While using duo-chrome test before refining cylindrical component with JCC it is assumed that circle of least confusion is on retina.

After determination of objective refraction using auto refractometer or retinoscopy, a monocular subjective refraction is carried out by the practitioner until best vision is obtained. Generally duo-chrome test is performed at the end of subjective refraction, even after astigmatism is corrected, duo-chrome at this stage is used to determine final sphere.

Methodology:

Ethical clearance to conduct the study was obtained from College Of Ophthalmology and Allied Vision Sciences, King Edward Medical University Lahore. A quasi experimental study was performed. From a study population of patients visiting Mayo Hospital Eye OPD for refraction, a study sample of 42 patients having astigmatic refractive error was selected. The study group was taken without discrimination of gender and excluding those who were mentally retarded, who had other pathological disorders of the eye, uncooperative patients, those who were not willing to share their data. Objective and subjective refraction was performed and verified using duo-chrome test and readings were recorded on self designed proformas. Visual acuity charts (Log MAR), trial lens and trial frames were used for refraction. SPSS version 22 was used for data entry of all types and its evaluation.

Paired samples T test was used to compare the results of duo-chrome test performed before and after cylindrical correction.

Results:

Table No 1:

	Mean	Std. Deviation	Std. error mean	t	Sig. (2-tailed)
Diff in Sph RX of RE after Duochrome - Diff in Sph+Cyl Rx of RE after Duochrome	0.05	0.27	0.04	1.22	0.22
Diff in Sph RX of LE after Duochrome - Diff in Sph+Cyl Rx of LE after Duochrome	0.02	0.25	0.03	0.75	0.45

Mean value of difference in spherical correction of right eyes after performing duo-chrome test was 0.61 ± 0.34 (Range: 0.00-1.25D) and that for left eyes was 0.53 ± 0.36 (Range: 0.00-1.25D), p-values with paired sample t-test is 0.22 for right eyes and 0.45 for left eyes of the patients, which shows that duo-chrome test results before and after cylindrical correction show no significant difference.

Table No 2:

	Mean	Std. Deviation	Std. error mean	t	Sig. (2-tailed)
Diff. b/w duochrome results RE- Diff. b/w duochrome results LE	0.01	0.27	0.04	0.28	0.78

Difference in duo-chrome test results of right eyes had a mean value of 0.07 ± 0.2 , and for left eyes it is 0.06 ± 0.24 . When results of duo-chrome test before and after correcting cylinder in both right and left eyes were compared with each other using paired sample T-test p value turned out to be 0.78 which shows that there is no significant difference among results of both eyes.

Discussion:

Subjective refraction is that in which trial lenses are used to find out the refractive error present in patient's eye. Many tests are present to finalize the end point of subjective refraction. One of these is duo-chrome test, also known as two colors or bichrome test. It makes use of red and green responses to find out at what point eye is in its emmetropic state. One side of the instrument is always red other can be green or blue. It relies on the fact that when seeing a distant object the

eye focuses on yellow part of visible spectrum. So, when eye has miscorrected or impaired refracted state green or red color can be seen clearly. In general, duo-chrome test is used to finalize only the spherical component of refraction. Though it isn't the best method yet it is in practice in the field. This study concludes that to whatever stage duo-chrome test is useful it can be used in astigmatic patients before and after correcting refractive cylinder.

A prospective study investigated usefulness of duo-chrome test for prevention of over correction,¹⁴ the study comprised of forty four myopic subjects with age ranging from six to twelve years the mean refractive correction was between -0.75D to -4.75D. Manifest refraction was performed on subjects and then duo-chrome was done, leading to cycloplegic refraction. There was no significant change in results of cycloplegic refraction and duo-chrome test which shows that duo-chrome is reliable to prevent over correction of refraction.

In the previous study carried out in Israel by Gantz et al,¹⁵ there was only representation of right eyes of the individuals while in the present study both right and left eyes of the individuals were observed, which shows that the results are applicable to both eyes of the individuals having astigmatism.

Out of 42 individuals included in the study right eyes of eight individuals were having simple myopic astigmatism, one simple hypermetropic, nine had mixed astigmatism and twenty-four compound myopic astigmats, while according to left eyes twelve were simple myopic, one simple hyperopic, six were having mixed astigmatism and twenty three were compound myopic astigmatics. In this study there was only one individual having simple hyperopic astigmatism in both right and left eyes which means that there is under representation of hyperopes while according to a study carried out in 2008 the prevalence of hyperopia in Pakistan is 27.1%.¹⁶ So, in a sample of 42 individuals there should be at least eleven hyperopic individuals, so it is possible that these results might not be applicable on hyperopic individuals. However, theoretically it is said that there is no difference of myopes or hyperopes on duo-chrome test.

Age of the individuals included in the study ranges from 15 to 58 years and no cycloplegic agents were used to control accommodation of eye, hence the results that duo-chrome test is equally reliable to be used



before or after cylindrical correction, may not be applicable to pediatric refraction in which cycloplegic agents are used. Also in old ages perplexing factor like media opacities occur which cause photophobia or other ocular problems, hence the study is also not applicable in such individuals.

Conclusion:

The duo-chrome test results before and after cylindrical correction in astigmatic patients were compared using paired sample T-test. It is concluded that there is no significant difference between the results of duo-chrome test before and after cylindrical correction. Hence, duo-chrome test is equally useful to be performed before or after correcting cylindrical component during refraction.

References:

1. Brinkbo B. Duochrome test as an aid in determinations of refraction. *Acta Ophthalmol.* 1954;32(5):585.
2. Emsley HH. *Visual Optics.* London: Halton Press; 1955.
3. Williamson-Noble FA, Dallos J, Mann I. Spherocylindrical contact lenses—a preliminary note. *The Br J Ophthalmol.* 1940;24(1):43.
4. Baranyovits PR. Stabilisation of refraction following cataract surgery. *Br J Ophthalmol.* 1988;72(11):815-9.
5. Pointer JS. A 6-year longitudinal optometric study of the refractive trend in school-aged children. *Ophthalmic Physiol Opt.* 2001;21(5):361-7.
6. Rosa N, Furgiuele D, Lanza M, Capasso L, Romano A. Correlation of changes in refraction and corneal topography after photorefractive keratectomy. *J Refract Surg.* 2004;20(5):478-83.
7. Bedford RE, Wyszecki G. Axial chromatic aberration of the human eye. *JOSA.* 1957;47(6):564.
8. Shilo S. A trichromatic test for spheric and astigmatic refraction. *Doc Ophthalmol.* 1977;43(1):159-64.
9. Kett CW. The bichrome test. *Clin Exp Optom.* 1936;19(11):525-9.
10. Keirl A, Christie C. (eds). *Clinical optics and refraction: A guide for optometrists, contact lens opticians and dispensing opticians.* Elsevier Health Sciences; 2007.
11. Colligon-Bradley P. Red-green duochrome test. *J Ophthalmic Nurs Tech.* 1992;11(5):220-2.
12. Anderson P. Cross Cylinders. *Clin Exp Optom.* 1923;5(8):170-5.
13. Loo A, Jacobs RJ. Jackson crossed cylinder axis test. *Optometry.* 1994:208
14. Yang SM, Kim SH, Cho YA. The usefulness of duochrome test for prevention of overcorrection in refraction tests of myopic children. *Korean J Ophthalmol.* 2006;47(2):269-72.
15. Gantz L, Schrader S, Ruben R, Zivotofsky AZ. Can the red-green duochrome test be used prior to correcting the refractive cylinder component? *PloS One.* 2015;10(3):0118874.
16. Shah SP, Jadoon MZ, Dineen B, Bourne RR, Johnson GJ, Gilbert CE, et al. Refractive errors in the adult Pakistani population: The national blindness and visual impairment survey. *Ophthalmic Epidemiol.* 2008;15(3):183-90.

A Authors' Affiliation

¹Maria Hussain

²Ayesha Saleem

³Rafia Roohi

⁴Tayyaba Bashir

⁵Zoya Hussain

College of Ophthalmology & Allied Vision Sciences, Lahore.