Peertechz

Journal of Clinical Research and Ophthalmology

CLINICAL GROUP

mail.ophthalmology@peertechz.com

Journal of Clinical Research and Ophthalmology OPEN ACCESS JOURNAL

ISSN: 2455-1414 DOI: https://dx.doi.org/10.17352/jcro

Research Article

Not dominance but the loss of binocularity determines the success of monovision

Veerle Van Severen[1]*, Sven Van Laere[2] and Marcel Ten Tusscher[1]

[1]Department of Ophthalmology, Vrije Universiteit Brussel, Belgium

[2]Interfaculty Center Data Processing and Statistics, Free University of Brussels, Brussels, Belgium

Received: 02 April, 2021
Accepted: 23 April, 2021
Published: 26 April, 2021

***Corresponding authors:** Dr. Veerle Van Severen, MD, Resident, Department of Ophthalmology, Universitair Ziekenhuis Brussel, Vrije Universiteit Brussel, Vrije Universiteit Brussel, Jette, België, Belgium, E-mail: veerle.vanseveren@uzbrussel.be, vvs1992@hotmail.com

Keywords: Monovision; Titmus; Ocular dominance; Stereopsis; Binocular rivalry

https://www.peertechzpublications.com

Check for updates

Abstract

Purpose: To determine whether ocular dominance strength influences success of monovision

Design: Single-center, prospective, double blind crossover. Subjects received contact lenses with reading addition added to the left eye in the first trial period and to the right eye in the second period so that the type of monovision was randomized and blinded for the test subject and the investigator.

Methods: 17 presbyopic subjects, aged 50-65, received conventional and crossed monovision, each for 2 weeks. Satisfaction, stereopsis (TNO, Titmus) and Snellen visual acuity were measured. Ocular dominance was examined according to Haidinger and +1D test.

Results: Pearson correlation coefficient between strength of ocular dominance and subject satisfaction was ρ=0.088 for the conventional and ρ=0.000 for the crossed group. 93% of subjects were most satisfied with the type of monovision that yielded the highest Titmus score. For the TNO test this was only 64%. A statistical significant interaction effect was shown for this relationship (ρ=0.019).

Conclusion: A significant correlation between dominance strength, refraction error and satisfaction could not be found. However, we observed that the highest stereopsis score according to the Titmus test was more likely to yield a higher satisfaction when comparing conventional and crossed monovision. When a physician opts for monovision correction, the Titmus test can be performed with test spectacles or contact lenses to decide which eye should be corrected for distance vision. The choice should be in favor of the correction that yields the best Titmus score.

Introduction

Monovision is a concept that was introduced in 1958 as a means to correct presbyopic patients for distance and near at the same time [1]. It entails that one eye is corrected for distance. Thus the objective for this eye is emmetropia. The fellow eye is corrected for near and will be rendered slightly myopic. Monovision proved successful in certain patients and is applied extensively [2]. At present monovision is used for contact lens wear and refractive surgery in patients with presbyopia and also in cataract surgery.

The notion of ghosting [3] and monocular blur [4] when focusing on either a distant or a near object may restrict satisfaction with monovision. During attempts to optimize the success of monovision, ocular dominance was supposed to be of influence. In this regard, the question arose whether the dominant eye should be targeted for distance (i.e. conventional monovision). In crossed monovision on the other hand the dominant eye is used for near vision, while the non-dominant eye is used for distance vision. Visual performance and patient satisfaction have been compared between crossed and conventional monovision in pseudophakia. Several studies found no significant difference between the conventional and crossed monovision group [5,6].

A more fundamental problem emerged: which eye is the dominant eye and how is this established? There is an abundance of ocular dominance tests in literature. These consist of broadly two groups, i.e. sensory and motor dominance tests. Studies showed no correlation between them [7,8]. So, this problem has not been resolved.

Citation: Van Severen V, Van Laere S, Ten Tusscher M (2021) Not dominance but the loss of binocularity determines the success of monovision. J Clin Res Ophthalmol 8(1): 018-022. DOI: https://dx.doi.org/10.17352/2455-1414.000087

Besides dominance, the influence of the refraction error of the participants was evaluated as a common denominator for monovision failure [9]. Significant difference in success with monovision between hyperopic and myopic test subjects was not established [10-12].

In the present study, we test whether strength of ocular dominance determines the success of monovision. Theoretically a very strong or very weak ocular dominance would result in failure of monovision due to monocular viewing in strong dominance and monocular blur or continuous binocular rivalry [13] in weak dominance. In this study we try to quantify ocular dominance using Haidinger brushes in a synoptophore [7]. This is at present the only test that offers a quantification of dominance. In addition the Plus one diopter (+1D) test for ocular dominance was applied [7], since this test best simulates the monovision correction.

We hypothesized that the success of monovision is influenced by the strength of ocular dominance and that the type of refraction error influences the preference for the type of monovision (i.e. conventional or crossed).

Methods

Design

A prospective power analysis for a two-group independent sample t-test was carried out with a significance level of 0.05. A standard deviation of 2 was applied, based on previous reported standard variation for the VF-14 questionnaire in other studies [14,15]. This questionnaire consists of 14 yes/no questions that gauge the visual difficulties that were experienced during the monovision trial, for example, during reading, driving or walking stairs. The power analysis showed that a sample size of 8 for each group (myopic and hyperopic) was necessary to obtain a significant result with a statistical power of 80%.

The present study entailed a prospective, single-centered, double blind, randomized, crossed study with 21 test subjects. The test subjects were recruited from the general consultation of the Ophthalmology department of the University hospital of Brussels. Inclusion criteria were: age 50-65, vision 10/10 with both eyes and myopia or hyperopia between 1 and 6 diopters. Exclusion criteria were astigmatism more than 3 diopters, strabismus or amblyopia, anisometropia greater than 2 diopters.

During a pre-trial evaluation the following tests were performed: Snellen chart for visual acuity at distance and Sloan letter near vision eye chart for near, objective refraction, Titmus and TNO test at near for stereopsis.

Haidinger and plus one diopter test

To determine the dominant eye, the Haidinger test and the +1D test were used. The Haidinger test is performed with a synoptophore with rotating light propellers which produce a revolving movement. One eye is shown a clockwise movement, the other a counterclockwise movement. The incongruent images induce binocular rivalry. The test subject is asked which direction of movement is seen. If both movements are observed, they are asked which one predominates. After designating the dominant eye, the intensity of light in that eye is reduced stepwise. The test subject is continuously asked to indicate the point of transition, i.e. moment when an opposite direction of movement was observed. The reduction of light intensity needed to reverse the movement was used as a degree of ocular dominance. This test was repeated until a consistent result was obtained. The +1D test was chosen because it approximates the condition induced by monovision, i.e. blurring one eye at distance and near. The test subject was asked whether blurring of the right or left eye was disturbing binocular vision, and if both were found to be hindering binocularity, which side was most bothersome.

Experiment

11 myopic subjects and 10 hyperopic subjects were included in the trial and received contact lenses with a reading addition (+2D) for the left eye. This way the investigator performing the tests before and after the trial period was unaware of the type of monovision applied.

After a two week contact lens trial period, the patient returned to repeat the pre-trial tests, and additionally a visual function questionnaire (VF-14) to quantify disturbance of binocular visual function and evaluate satisfaction ishimoto & Ohtsuki 2012 [16].

Subsequently, after a two week washout period, the trial period was repeated with a new pair of contact lenses in which the right eye received the reading addition (+2D). After the second trial period, the satisfaction questionnaire and pre-trial tests were repeated (Figure 1).

Four test subjects dropped out of the study during or after the first trial period. The reasons for dropout were: significant disturbance of daily activities with monovision correction (n=2) and contact lens intolerance (n=2). The number of subjects that completed the study was 17, 8 myopic and 9 hyperopic (Figure 2).

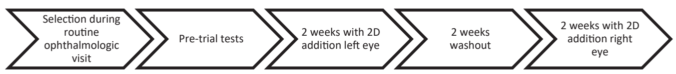

Figure 1: Flow chart study design.

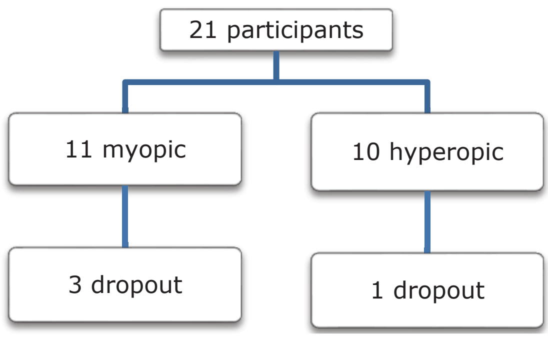

Figure 2: Study population.

Citation: Van Severen V, Van Laere S, Ten Tusscher M (2021) Not dominance but the loss of binocularity determines the success of monovision. J Clin Res Ophthalmol 8(1): 018-022. DOI: https://dx.doi.org/10.17352/2455-1414.000087

Statistical analysis

Linear regression modeling was used to verify the relationship between satisfaction and ocular dominance strength. Correlation between satisfaction and ocular dominance strength was expressed using the Pearson correlation coefficient. Satisfaction was then categorized to give a qualitative measurement of what worked best for that specific test subject. This qualitative measure of satisfaction was used in a logistic regression to model the relation with the test used and the stereopsis measured. An interaction between both the test used and stereopsis was included in the model to express difference. Main and interaction effects were expressed in terms of odds ratios (OR) and their 95% confidence intervals (95% CI) accompanied by their ρ-value.

Ethics

Before the start of the study the Medical Ethical Committee of the University Hospital of Brussels was consulted. A favorable advice was given for the study (B.U.N. 143201630722) on July 3, 2018.

Results

Statistical analysis of the correlation between ocular dominance strength and satisfaction revealed a Pearson correlation coefficient ρ=0.088 in the conventional monovision group and ρ=0.000 in the crossed monovision group, which indicates a negligible correlation (Figures 3,4).

Satisfaction outcomes of the hyperopic group and myopic group are comparable in conventional and crossed monovision. This result remains the same when we determine the dominance with the Haidinger and the + 1D test. There is no statistical difference in the preference for conventional or crossed monovision in the myopic and hyperopic test groups (Figure 5).

The type of monovision with the highest Titmus score had the highest satisfaction score. However, the amount of loss of Titmus score did not parallel the loss in satisfaction. This is why both parameters were dichotomized before statistical analysis. They were categorized as highest and lowest for the stereopsis score and as least and most satisfied for the satisfaction score for each subject.

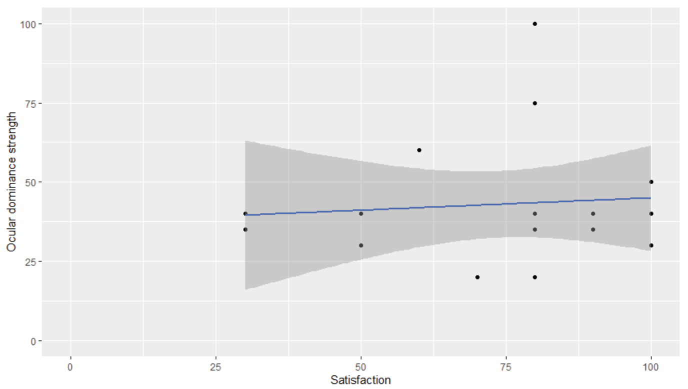

Figure 3: Ocular dominance strength versus satisfaction in conventional monovision.

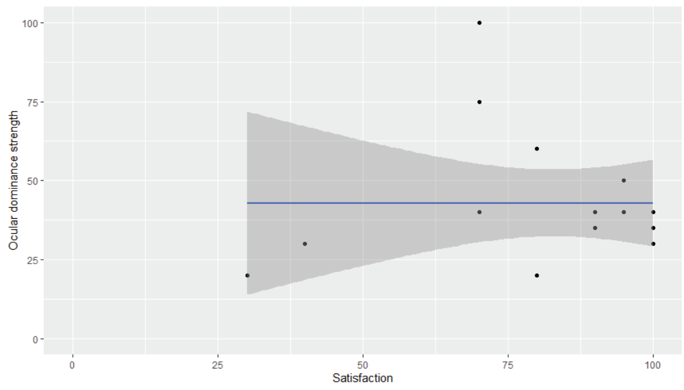

Figure 4: Ocular dominance strength versus satisfaction in crossed monovision.

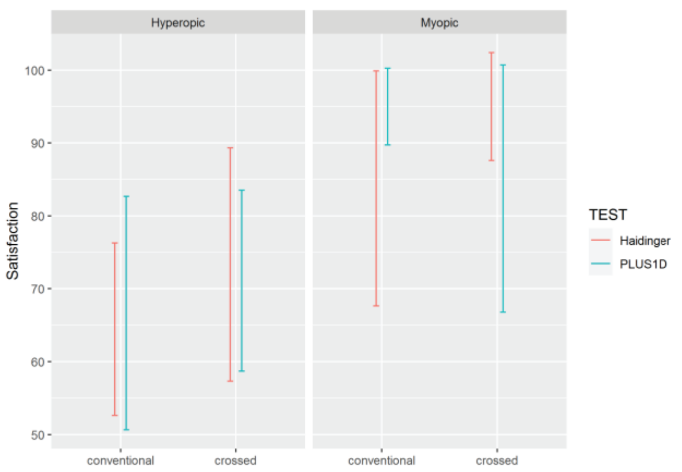

Figure 5: Comparison in satisfaction with conventional and crossed monovision (as determined by Haidinger test and Plus one diopter test) in the myopic and hyperopic groups.

For the Titmus test, the lowest measurements cluster was found in the least satisfied group while the best measurements cluster in the most satisfied group. This same effect was not observed with the TNO test. 93% (13/14) of subjects were most satisfied with the type of monovision that yielded the highest Titmus score. For the TNO test this was only 64% (7/11) (Table 1). The discrepancy in number of subjects is caused by subjects that had the same level of stereopsis for both types of monovision.

A logistic regression analysis was performed after dichotomization of the data to test this interaction effect between the test and the stereopsis measured (Table 2). The interaction between the test and stereopsis showed that the TNO test with the highest stereopsis is less likely to score better in terms of satisfaction compared to the Titmus test (OR=0.018, p=0.019).

Discussion

The present study showed that the distribution of satisfaction does not correlate with the ocular dominance strength. The different ocular dominance strength measurements do not show a positive or negative correlation with the satisfaction in both groups (i.e. conventional and crossed), as shown in

Citation: Van Severen V, Van Laere S, Ten Tusscher M (2021) Not dominance but the loss of binocularity determines the success of monovision. J Clin Res Ophthalmol 8(1): 018-022. DOI: https://dx.doi.org/10.17352/2455-1414.000087

Table 1: Satisfaction on stereopsis measured for both the Titmus and TNO test.

		Satisfaction	
		Most satisfied	Least satisfied
Stereopsis (Titmus test)	Highest score	13	1
	Lowest score	1	13
Stereopsis (TNO test)	Highest score	7	4
	Lowest score	4	7

Table 2: Logistic regression explaining satisfaction (lowest versus highest) in terms of stereopsis measured qualitatively for both the Titmus and TNO test.

	OR	95% CI for OR		P-Value
Stereopsis				< 0.001
Lowest	(Ref.)			
Highest	169.000	15.121	6512.059	
Test				0.098
Titmus	(Ref.)			
TNO	7.429	0.887	161.365	
Interaction	0.018	0.000	0.039	0.019

a virtually flat trend line in both graphics. We hypothesized that a very strong or very weak ocular dominance would result in failure of monovision because of monocular viewing (in strong dominance) or continuous binocular rivalry (in weak dominance). Dominance strength throughout the study population however showed inadequate numbers of truly strong and weak ocular dominance. The test population displayed a discretely skewed dominance strength. This may be one of the reasons why no correlation was established.

Furthermore, a preference for conventional of crossed monovision could not be found in the myopic or hyperopic groups. Similar results were obtained when dominance was determined by the Haidinger and the +1D test. The Haidinger test is the only test found in literature to designate and quantify ocular dominance. Nevertheless this test may not adequately point out the dominant eye. In literature there's an abundance of ocular dominance tests described, containing sensory and motor tests. A concordance between these tests has not been established. Probably dominance is task related. This was also concluded by Evans after a thorough review of monovision and ocular dominance [2].

Eye dominance is often perceived as an all-or-nothing response in which in certain situations the input of one eye is suppressed and the other eye dominates the visual perception [12]. This is certainly true for some parts of the visual field which can only be viewed monocularly, for example the most temporal part that is projected on the nasal retina. The part of the visual field that is viewed binocularly may have a patchy distribution of ocular preference. This means that ocular dominance likely is a jigsaw puzzle with patches from both eyes that form one perceived image. The preference or dominance of one eye over the other is then determined by the projection of the viewed object on the retina of the left and right eye. This would explain why the different ocular dominance tests render variable results without concordance between these tests.

Finally, we observed that the strength of stereopsis did not directly correlate with the amount of satisfaction, but an interaction was observed qualitatively. For this reason the data were dichotomized into highest and lowest score for the parameters stereopsis and satisfaction. When both types of monovision (i.e. conventional and crossed) showed a difference in satisfaction, it was the type of monovision with the highest stereopsis Titmus score that was preferred by the subject. Although it seems apparent that loss of stereopsis is associated with loss of satisfaction, a similar result was not obtained with the TNO stereopsis test. 93% of subjects preferred the type of monovision that yielded the highest stereopsis score according to the Titmus test, for the TNO test this was only 63%. So, a TNO test with the highest stereopsis is less likely to score better in terms of satisfaction compared to the Titmus test.

As to the discrepancy found between the Titmus and the TNO test, the TNO test is a random dot stereotest that requires global stereopsis, since no monocular clues are available. It requires bifoveal fixation. This is lost during monovision because of refractional blur of one eye. The Titmus test, however, uses monocular clues and thus requires only localized stereopsis, for example peripheral fusion in the absence of bifoveal fixation [17]. This is somehow similar to the monovision condition and therefore may correlate with the result.

In summary, our findings suggest that the Titmus stereopsis test can be useful when evaluating what type of monovision should be applied (i.e. conventional or crossed). This way satisfaction with monovision can be optimized in the population for which monovision is a suitable option. The Titmus test score cannot be used as a predictor for the success of monovision. This is why a thorough personal evaluation of a patient and a trial period remain necessary before opting for monovision.

Limitations of the study

Mini-monovision (e.g. +1.25 D) is more often applied then full monovision. Reducing the level of anisometropia yields better stereo-acuity and improves contrast sensitivity. In this study full monovision was chosen, i.e. +2.00 D. Overall results may be better with mini-monovision.

In refractive surgery and clear lens exchange a Titmus test is easily performed preoperative. In the context of cataract, visual acuity is reduced and a myopisation frequently occurs due to nuclear cataract. This may lead to suboptimal and thus insufficient visual acuity for stereo-acuity testing. If the cataract development is asymmetrical, an anisometropia may develop. This also will reduce stereopsis.

VF-14 questionnaire is validated for quality of vision in patients with cataract, it is not validated for the purpose of monovision.

The monovision trial period chosen was 2 weeks. It is uncertain if a longer period of adaption influences the results.

References

1. Westsmith RA (1958) Uses of a monocular contact lens. Am J Ophthalmol 46: 78-81. **Link:** https://bit.ly/3aAoz1z

Citation: Van Severen V, Van Laere S, Ten Tusscher M (2021) Not dominance but the loss of binocularity determines the success of monovision. J Clin Res Ophthalmol 8(1): 018-022. DOI: https://dx.doi.org/10.17352/2455-1414.000087

2. Evans BJ (2007) Monovision: a review. Ophthalmic and Physiological Optics 27: 417-439. Link: https://bit.ly/3xlhwDV
3. Collins MJ, Goode A (1994) Interocular blur suppression and monovision. Acta Ophthalmol 72: 376-380. Link: https://bit.ly/3gFD3Rw
4. Back A (1995) Factors influencing success and failure in monovision. International Contact Lens Clinic 22: 165-172.
5. Kim J, Shin HJ, Kim HC, Shin KC (2015) Comparison of conventional versus crossed monovision in pseudophakia. Br J Ophthalmol 99: 391-395. Link: https://bit.ly/3dFKgzk
6. Zhang F, Sugar A, Arbisser L, Jacobsen G, Artico J (2015) Crossed versus conventional pseudophakic monovision: Patient satisfaction, visual function, and spectacle independence. J Cataract Refract Surg 41: 1845-1854. Link: https://bit.ly/3vf3wtu
7. Seijas O, de Liaño PG, de Liaño RG, Roberts CJ, Piedrahita E, et al. (2007) Ocular dominance diagnosis and its influence in monovision. Am J Ophthalmol 144: 209-216. Link: https://bit.ly/3xl2jm4
8. Malott LE, Clare DP, Lowther GE (1996) Ocular dominance testing. International Contact Lens Clinic 23: 50-54. Link: https://bit.ly/3xj5VVO
9. Risovic DJ, Misailovic KR, Eric-Marinkovic JM, Kosanovic-Jakovic NG, Milenkovic SM, et al. (2008) Refractive errors and binocular dysfunctions in a population of university students. Eur J Ophthalmol 18: 1-6. Link: https://bit.ly/2QrSSAD
10. Braun EH, Lee J, Steinert RF (2008) Monovision in LASIK. Ophthalmology 115: 1196-1202. Link: https://bit.ly/3nci8H2
11. Goldberg DB (2003) Comparison of myopes and hyperopes after laser in situ keratomileusis monovision. J Cataract Refract Surg 29: 1695-1701. Link: https://bit.ly/3az0ecm
12. Tuwir I, Kirwan C, Mustafa MS, O'Keefe M (2016) Stereopsis and Patient Satisfaction in Myopic and Hyperopic Individuals Selecting Monovision Correction by LASIK or LASEK. J Clin Exp Ophthalmol 7: 4. Link: https://bit.ly/2QRYJzi
13. Alais D, Blake R (2005) Binocular rivalry. MIT press. Link: https://bit.ly/3azYobh
14. Chiang PPC, Fenwick E, Marella M, Finger R, Lamoureux E (2011) Validation and reliability of the VF-14 questionnaire in a German population. Invest Ophthalmol Vis Sci 52: 8919-8926. Link: https://bit.ly/3guLIGA
15. Alonso J, Espallargues M, Andersen TF, Cassard SD, Dunn E, et al. (1997) International applicability of the VF-14: An index of visual function in patients with cataracts. Ophthalmology 104: 799-807. Link: https://bit.ly/3gzPrTg
16. Kishimoto F, Ohtsuki H (2012) Comparison of VF-14 scores among different ophthalmic surgical interventions. Acta Medica Okayama 66: 101-110. Link: https://bit.ly/3ve6bnb
17. Fricke TR, Siderov J (1997) Stereopsis, stereotests, and their relation to vision screening and clinical practice. Clinical and Experimental Optometry 80: 165-172. Link: https://bit.ly/2PgrDsr

Citation: Van Severen V, Van Laere S, Ten Tusscher M (2021) Not dominance but the loss of binocularity determines the success of monovision. J Clin Res Ophthalmol 8(1): 018-022. DOI: https://dx.doi.org/10.17352/2455-1414.000087