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Optical coherence tomography profile of macular structure and ocular dominance in young adults

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Background: Ocular dominance is used clinically for decisions on monovision in contact lens wear and treating binocular vision anomalies.

Aim: This study aimed to investigate the association between macular structure and ocular dominance in normal-sighted young adult Sudanese by using optical coherence tomography (OCT).

Setting: The study was conducted at Al-Neelain eye hospital, Faculty of optometry and visual sciences, Khartoum, Sudan.

Methods: A prospective, cross-sectional and comparative study was conducted in 160 eyes of 80 healthy young adults. Central macular thickness (CMT), peripapillary retinal nerve fibre layer (NFL) thickness and inner retinal layers were investigated in each subject using OCT. Hole-in-the-card was used to detect ocular dominance.

Results: The findings showed that the mean value of CMT for dominant eyes was slightly thicker (224.53 ± 17.18 μm) than in non-dominant eyes (224.36 ± 16.18 μm; $P = 0.947$). Whereas NFL thickness for dominant eyes was thicker at 31.87 ± 10.43 μm than in non-dominant 130.83 ± 10.30 μm with $P = 0.528$. In general, there were no highly significant differences between dominant eyes and non-dominant eyes found in macular parameters ($P > 0.05$).

Conclusion: Central macular thickness, NFL, ganglion cell layer and retinal pigmented epithelium may have some impact on determining ocular dominance in healthy adults. We believe that the exact mechanism and effects of ocular dominance remain unclear. Thus, further evaluation is needed.

Contribution: This study observed slight thicker in macular parameters for the dominant eye, particularly in CMT and NFL thickness.

Keywords: central macular thickness; ganglion cell; inner plexiform; nerve fibre layers; retinal pigmented epithelium; ocular dominance.

Introduction

Dominance refers to the preference most humans show for one side of their body over the other to do activities like writing, eating or sports especially in asymmetrical sports, which require the preferential use of one side of the body.[1,2] Whereas functional dominance happens in the paired organs of the body, such as hands, legs, eyes, ears and cerebral hemispheres; the exact mechanisms resulting in dominance as well as the strength and quality of lateralisation remain unclear.[2,3,4] Eye dominance is the superiority or preference of one eye over the other for visual, sensory and oculomotor tasks in individuals with similar vision and other extraocular structures. Conversely, on those with pathological features or ocular defects such as the presence of anisometropia, paralysis of extraocular muscles, unilateral cataract or other aspects that would tend to determine which eye with manifest suppression and therefore be the non-dominant eye, the preference could be easily understood.[5,6,7,8]

Visual signals commonly travel through the optic pathway to reach the primary visual cortex. The layers of the cortex receive input from both eyes or binocularly, except for layer 4C, which exclusively receives input from contralateral eye.[8] The secondary visual cortex recognises

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complex visual components and communicates with the primary cortex. The association cortex integrates multisensory information.[8,9] The common believe that the ocular dominance arises from the distinct processing of visual information from each eye. Therefore, dominant eye activates the cortex more than the non-dominant eye. Research conducted in laboratories has identified dominant columns within the primary cortex, which play a crucial role in the processing of monocular information.[8]

Visual dominance has been of interest to eye care professionals such as ophthalmology, optometry and other fields of science such as sports, biology and psychology.[4,10] Previously published studies showed conflicting results about ocular dominance, some authors suggest that neural bases in the primary visual cortex in the brain.[11,12,13] Others suggested that the brain is lateralised for the hands or legs but not for the eyes, whereas others report that better function and structure could be the cause and some proposed hereditary origin for dominancy.[14,15,16,17] Some theories hypothesised that the ocular dominance connected with brain asymmetry would affect the macular structure. However, the reality is that although all these contradicted theories the exact truth about ocular dominance in normal sight remains unidentified and the mechanisms resulting in dominance as well as the strength and quality of lateralisation remain ambiguous.[18.19]

As mentioned above by earlier studies regarding ocular dominance the mechanism and causes were unclear. Despite the lack of clarity in this area, ocular dominance is used clinically, for example, as the basis for decisions on monovision in contact lens wear, sports vision and the treatment of binocular vision anomalies.[20] Recently with the development of modern technology in measuring the visual system functionally and structurally it could be possible to put these theories to the test. Therefore, the present study aims to investigate the association between macular structure and ocular dominancy in normal-sighted young adult Sudanese by using optical coherence tomography (OCT).

Methods

Study design

A prospective cross-sectional and comparative study was conducted at Al-Neelain eye hospital, Faculty of optometry, Khartoum, Sudan. Data were gathered from 160 eyes of 80 healthy young adults.

Inclusion criteria

Eighty subjects (160 eyes), who were young adult healthy emmetropic students in the faculty of optometry- Al-Neelain University, Students were accepted to participate and signed an informed consent. Participation was entirely voluntary. However, participants' age should be from 18 to 28 years, and all had standard visual acuity or better for both eyes according to the Log minimum angle of resolution (MAR) chart notation.

Exclusion criteria

Exclusion criteria were any systemic diseases, a history of ocular surgery, ocular diseases (e.g. corneal opacity or irregularity, dry eye, amblyopia, glaucoma and retinal abnormalities) and medications that might affect the eyes. Participants exhibited refractive errors from +0.50 to -0.50 dioptre spherical equivalent.

Ethical considerations

Ethical approval for conducting the study was obtained from the Al-Neelain University Institutional Review Board (No. NU-IRB-19-10-10-35). The study was conducted following the ethical standards of the Declaration of Helsinki. Informed consent was obtained from all participants, and the purpose of the study and any associated risks following eye checks were explained to them. The collected evidence was saved privately, and no personal information was obtained. The participants take part without restrictions; they can withdraw from the study at any time without any justification.

Ocular dominance detection

Eye dominance in sighting was determined by a hole-in-the-card test, in which each participant was given a card with a small hole in the centre and instructed to hold it in both hands about 40 cm from their eyes and was asked to see a distant object through the hole with his eyes open. The researcher then alternates which eye is closed, or the participant slowly pulls the aperture back towards the head to determine which eye is viewing the object and is thus the dominant eye. For each participant, the test was performed at least three times, and two more different techniques were used near point of convergence (NPC) and pointing tests for confirmation.

Clinical examinations

Participants underwent a comprehensive ocular examination, general history and a complete optometric examination, which included outer eye inspection using the slit lamp, vision by Log MAR chart, refraction by Topcon auto-ref-keratometer (KR.89000, version 1.25). Macular parameters were measured by REVO-80 OCT version 11.0.2. OPTOPOL technology, through retina 3D 10 × 10 protocols. Measurements were included the average thickness of the peripapillary retinal nerve fibre layer (PNFL), central macular thickness (CMT), the retinal pigmented epithelium (RPE), nerve fibre layer (NFL), ganglion cell layer (GCL) and inner plexiform Layer (IPL) for both dominance and non-dominance eye.

Data analysis

For statistical analysis, SPSS version 23.0 (SPSS Inc., Chicago, IL, USA) was used to analyse data. Descriptive statistics were obtained (frequency, percentage, mean and standard deviation). Paired samples t-test was used to compare mean of all macular parameters to test for statistically significant differences in between the dominant and non-dominant eye.

TABLE 1: Shows the macular parameters of the dominant and non-dominant eyes.

Variable average thickness by μm	Mean ± s.d.		*P*	95% CL of the difference	
	Dominant eyes	Non-dominant eyes		Lower	Upper
Central macular	224.53 ± 17.18	224.36 ± 16.18	0.947	–5.03	5.38
Nerve fibre layer	131. 87 ± 10.43	130.83 ± 10.30	0.528	–2.20	4.27
GCL+IPL+NFL†	113.86 ± 15.33	113.48 ± 15.98	0.345	–4.51	5.26
Retinal pigmented epithelium layer	182.76 ± 13.87	182.66 ± 14.54	0.956	–4.33	4.53

†, Ganglion cell layer or inner plexiform layer or nerve fibre layer.

Results

The mean age of the participants was 21.94 ± 1.87 years, with a range from 18 to 28 years. There were 65 (81.2%) females and 15 (18.8%) males who met the inclusion criteria for this study. A total of 60 participants (75%) had right dominant eyes, while 20 (25%) participants had left dominant eyes. The mean refractive error was 0.009 ± 0.32 dioptre in the dominant eyes and 0.009 ± 0.34 dioptre in the non-dominant eyes.

Table 1 shows the mean macular parameters and NFL values for the dominant and non-dominant eyes. Both dominant and non-dominant eyes had almost similar average macular thickness values. The mean value of CMT for dominant eyes was slightly thicker (224.53 ± 17.18 μm) than in non-dominant eyes (224.36 ± 16.18 μm); the difference was not statistically significant with a p-value of 0.947. Whereas NFL thickness for dominant eyes was thicker at 131.87 ± 10.43 μm than in non-dominant (130.83 ± 10.30 μm); the difference was not statistically significant with a p-value of 0.528.

There was no highly statistically significant difference between dominant 113.86 ± 15.33 μm and non-dominant eyes 113.48 ± 15.98 μm in GCL/IPL/NFL thickness (P = 0.345). In terms of RPE, layer thickness in dominant eyes was found 182.76 ± 13.87 μm compared to non-dominant eyes 182.66 ± 14.54 μm with a p-value of 0.956. Furthermore, the study revealed that there is no statistically significant correlation between ocular dominance on one hand and age (*P-Value* 0.690) and gender (*P-Value* 0.734) on the other hand.

Discussion

The findings of this study showed that most of the participants had right-dominant eyes, while the mean value of CMT for dominant eyes was slightly thicker than in non-dominant eyes; but the difference was not statistically significant (P = 0.947). Furthermore, our study found that the NFL thickness for dominant eyes was thicker than in non-dominant, but also the difference was not statistically significant with P = 0.528. In general, there were no highly significant differences between dominant eyes and non-dominant eyes found in macular parameters $P > 0.05$. Our findings agreed with previously published studies[1,10,16,17.18,19,20] that reported that most of the world population has the right eye as a dominant eye.

Even though the macula generates most of the visual output for the higher brain centres, it is thought that the dominant eyes have more neural connections with the brain.[13] Our study findings showed that the macular parameters for both the dominant and non-dominant eye are displayed in Table 1; the dominant eye has a slightly high values in CMT, NFL, inner layer thickness, NFL thickness and RPE than in non-dominant while the differences were not statistically significant. Therefore, it can be said that there are no statistically significant differences in retinal features for dominant and non-dominant eyes. The present finding is confirmed by many works of literature[21,22,23,24] showing compatible results while Jiménez-Santos et al. and Samarawickrama et al. found the same finding despite they studied younger age groups (6–12 years).[23,24] However, contrary to our study findings, some studies reported a significant difference between the dominant and non-dominant eyes in the macular ganglion cell-inner plexiform layer.[25,26]

Moreover, some studies found that there are no significant changes in retinal and macular structure for normal and amblyopic eyes (anisometropic amblyopia) in children. This finding agreed with the point of view revealed that the function is the main predictor of dominance, whether in normal or abnormal conditions.[27] This finding does not contradict with those results that state that ocular dominance is determined by the brain rather than the peripheral organ itself.[24] However, as most of the visual cortex is devoted to macular activity, a possible explanation is that the macula has an indirect influence on the summation process.[28] Whereas other studies suggested that the difference may be found at the blood supply level rather than the anatomical structure of the macula.[29] Furthermore, to explore this possibility, we propose that future studies be carried out to assess the ocular choroidal and visual cortex structure and macular cone characteristic and function differences between dominant and non-dominant eyes.

Conclusion

This study revealed that no significant difference in retinal morphological structures was found to be associated with ocular dominance and non-dominance in the normal-sighted young population. However, our study observed slight thicker in macular parameters for the dominant eye, particularly in CMT and NFL thickness. Further studies should be performed to assess the choroidal and the visual cortex structure for dominant and non-dominant eyes in different age groups.

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Competing interests

The author(s) declare that they have no financial or personal relationship(s) that may have inappropriately influenced them in writing this article.

Authors' contributions

S.I.E.H. was the project leader who was responsible for the experimental and project design under the supervision of A.B.M.A., A.E.M.E. and S.H.A. S.I.E.H. conducted all clinical research. R.F.M., A.E.M.E. and S.H.A made conceptual contributions and provided guidance for the study. S.I.E.H. was responsible for the writing of this article with input and edits from A.B.M.A., A.E.M.E., S.H.A. and R.F.M.

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Data availability

The data are available from the corresponding author, A.E.E., on reasonable request.

Disclaimer

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