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THE EFFECT OF CORNEAL ASTIGMATISM ON RETINAL NERVE FIBER LAYER THICKNESS AND OPTIC NERVE HEAD MEASUREMENTS BY OPTICAL COHERENCE TOMOGRAPHY

By

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ABSTRACT

Background: Optical Coherence Tomography (OCT) is a non-invasive investigative technique that functions as a type of optical biopsy. It has been an important diagnostic tool in evaluation of optic nerve head (ONH) and macula. Evaluation of OCT ONH is essential, since the thickness of the RNFL and ONH parameters can be affected in various optic neuropathies like glaucoma, optic atrophy and optic disc edema.

Objective: To evaluate the effect of corneal astigmatism on retinal nerve fiber layer (RNFL) thickness and optic nerve head (ONH) parameters measured with spectral-domain optical coherence tomography (OCT).

Methods: Forty eyes of 32 patients were included in this study.Group I; 20 non/low astigmatic eyes to be compared with Group II; 20 astigmatic eyes (10 eyes have with the rule corneal astigmatism WTR and 10 eyes have against the rule corneal astigmatism ATR). The average corneal astigmatism in group I was -0.33±0.17 D (range -0.5-0 D), in group II it was -3.18±0.87 D (range -4.5- -2 D) in eyes of with the rule corneal astigmatism, and -3.13±0.84 D (range -4.5- -2.25 D) in eyes of against the rule corneal astigmatism. All forty eyes underwent full ophthalmic examination and performed OCT ONH imaging by SD-OCT Angio Vuein Ophthalmology Department, Faculty of Medicine, Al-Azhar University, Cairo, from January to November 2019.

Results: No significant difference was noted in the disc area, rim area, vertical C/D ratio and cup volume (all P values > 0.05). There were no significant differences between the two groups in global average RNFL thickness, as well as superior, inferior, nasal and temporal quadrant RNFL thickness (P values > 0.05).

Conclusions: corneal astigmatism had statistically insignificant effect on optic nerve head parameters and retinal nerve fiber layer thickness measured with spectral domain optical coherence tomography.

Key words: Astigmatism, Optic nerve, Optical coherence tomography.

INTRODUCTION

OCT utilizes a concept known as "interferometry" to create a cross-sectional image that is accurate to within at least 10-15 microns. It was first introduced in 1991 *(Potsaid et al., 2010).*

Evaluation of OCT ONH is essential, since the thickness of the RNFL and ONH parameters can be affected in various optic neuropathies like: glaucoma *(Mwanza et al., 2010* and *Hayreh, 2011)* ischemic optic neuropathy *(Bourne, 2012)*

and optic disc edema *(Martinez and Ophir, 2011)*.

Many studies have reported that many factors including refractive errors *(Lee et al., 2011)*, axial length *(Kang et al., 2010)*, myopic optic disc tilt *(Hwang et al.,2012 -a)*, eccentric scan location and head tilt during the examination can affect the OCT measurements, cataract *(Kim et al., 2012)*, vitreous opacities *(Hwang et al., 2012 -b)*, signal strength *(Samarawickrama et al., 2010)* and pupil dilation *(Savini et al., 2010)*, while little is known about the effect of astigmatism on RNFL and ONH parameters measured by OCT.

Astigmatism is a common refractive error, which occurs due to imperfection in curvature of cornea or less commonly crystalline lens *(Hoffmann and Hütz, 2010)*. In eyes with astigmatism, retinal images can be distorted to an ellipse and the image size could vary according to the axis of astigmatism. Some studies showed that corneal astigmatism can affect OCT measurements of both RNFL thickness and ONH parameters *(Liu et al., 2012)*.

This work is aimed to evaluate the effect of corneal astigmatism on retinal nerve fiber layer thickness and optic nerve head measurements by optical coherence tomography.

PATIENTS AND METHODS

Forty eyes data were divided into two equal groups:

Group I "Non/low corneal astigmatism" and Group II 'High corneal astigmatism' who were divided into equal subgroups: with the rule (WTR) and against the rule (ATR).

Inclusion criteria:

- High astigmatic eyes at least 2 D astigmatism.
- Non/low astigmatic eyes not exceeding 0.5 D astigmatism.
- Within normal IOP.
- Within normal C/D ratio.

Exclusion criteria:

- Diagnosed or suspected glaucoma.
- Retinal lesions (eg, degenerative myopia, diabetic retinopathy, retinal dystrophies).
- History of intra-ocular surgery or trauma.
- Corneal opacity or scar.
- Patients with systemic disease including (HTN, DM, collagen vascular disease)
- Patients with neurological disease including (demyelinating disease, SOL, IIH).
- Patients with optic atrophy or history of optic neuropathy (inflammatory, ischemic, traumatic, compressive).

Patient assessment:

- History taking: Glasses, ocular surgery, trauma, systemic and neurological disease.
- Visual assessment: Refraction by auto-refractometer, visual acuity.
- Corneal astigmatism assessment by auto-keratometer by KR-800 Auto Kerato/Refractometer (Topcon, Tokyo 174-8580, Japan).
- Intraocular pressure measurement with Goldmannapplanation tonometer.

- Slit lamp examination.
- Fundus examination with 90-D lens.

OCT imaging:

All forty eyes performed OCT ONH by SD-OCT: AngioVue (Optovue,6 Northport loop, west Fremont, CA, USA). With taking care for patients to be well positioned avoiding head tilt.

Statistical analysis:

Recorded data were analyzed using the statistical package for the social sciences, version 20.0 (SPSS Inc., Chicago, Illinois, USA). Quantitative data were expressed as mean± standard deviation (SD). Qualitative data were expressed as frequency and percentage. A one-way analysis of variance (ANOVA) when comparing between more than two means. Post Hoc test: Least Significant Difference (LSD) was used for multiple comparisons between different variables. Kruskal Wallis test was used for multiple-group comparisons in non-parametric data. Mann Whitney U test was used for two-group comparisons in non-parametric data. Chi-square (x2) test of significance was used in order to compare proportions between qualitative parameters. A p value ≤0.05 was considered statistically significant.

RESULTS

Mean age of group I was 33.05 ± 9.41 ranges 21-52. Mean age of group II WTR was 35.90 ± 9.12 with range of 26-54. Mean age of group II ATR was 36.60±10.29 with range of 20-52. Regarding male (M) and female (F) distribution: group I had 11F and 9M, group II WTR had 4F and 6M and group II ATR had 4F and 6M. Correlation analysis showed insignificant difference among groups regarding age and sex (p-value 0.568 and 0.741 respectively). Average corneal astigmatism in group I was -0.33±0.17 D with range of -0.5-0 D, and in group II WTR was -3.18±0.87 D with range of -4.5- -2 D, and -3.13±0.84 D with range of -4.5- -2.25 D in group II ATR **(Table 1)**.

Table (1): Comparison between: Low corneal astigmatism, WTR corneal astigmatism and ATR corneal astigmatism according to refractive state

Groups / Refractive state	Low corneal astigmatism (n=20)	With the rule high corneal astigmatism (n=10)	Against the rule high corneal astigmatism (n=10)	Kruskal Wallis test	p-value
Total astigmatism					
Mean±SD	-0.38 ± 0.24	-3.25 ± 0.96	-3.18 ± 0.76	29.633	<0.001
Median (IQR)	-0.38 (0.25)	-3.13 (1.5)a	-3.13 (1.38)a		
Range	-0.75- 0	-5- -2	-4.5- -2.25		
Corneal astigmatism					
Mean±SD	-0.33±0.18	-3.18±0.87	-3.13±0.84	29.711	<0.001
Median (IQR)	-0.25 (0.25)	-3.00 (1.44)a	-2.88 (1.63)a		
Range	-0.5- 0	-4.5- -2	-4.5 -2.25		

Using: Kruskal Wallis Test
IQR: Interquartile range
Mann-Whitney test: a: significant difference with low corneal astigmatism; b: significant difference with the rule high corneal astigmatism

Analyzed data of ONH parameters revealed mean disc area in group 1 was1.80±0.21, in group 2 WTR was 1.90±0.20and in group 2 ATR was 1.95±0.15, with insignificant difference among the groups. Regarding mean rim area in group 1 was 1.33±0.09, in group 2 WTR was 1.22±0.11and in group 2 ATR was 1.24±0.10, with insignificant difference among groups. Regarding mean vertical C/D ratio in group 1 was 0.34±0.08, in group 2 WTR was0.41±0.07 and in group2 ATR was0.42±0.07, with insignificant difference among groups. Regarding mean cup volume in group 1 was 0.120±0.109, in group2 WTR was0.143±0.067 and in group 2 ATR was 0.134±0.083 with insignificant difference among groups **(Table 2)**.

Table (2): Comparison between Low corneal astigmatism, (WTR) corneal astigmatism and (ATR) corneal astigmatism according to disc parameters

Groups / Disc Parameters	Low corneal astigmatism (n=20)	With the rule high corneal astigmatism (n=10)	Against the rule high corneal astigmatism (n=10)	Kruskal Wallis test	p-value
Disc area					
Mean±SD	1.80±0.21	1.90±0.20	1.95±0.15	5.189	>0.05
Median (IQR)	1.80 (0.27)	1.87 (0.30)	1.97 (0.26)		
Range	1.43- 2.23	1.56- 2.23	1.67- 2.18		
Rim area					
Mean±SD	1.33±0.09	1.22±0.11	1.24±0.10	1.797	>0.05
Median (IQR)	1.26 (0.15)	1.21 (0.18)	1.24 (0.17)		
Range	1.19- 1.54	1.03- 1.42	1.1- 1.38		
Vertical C/D ratio					
Mean±SD	0.34±0.08	0.41±0.07	0.42±0.07	5.344	>0.05
Median (IQR)	0.36 (0.08)	0.40 (0.11)	0.42 (0.10)		
Range	0.21- 0.52	0.29- 0.49	0.29- 0.53		
Cup volume					
Mean±SD	0.120±0.109	0.143±0.067	0.134±0.083	2.206	>0.05
Median (IQR)	0.09 (0.12)	0.16 (0.11)	0.16 (0.16)		
Range	0.021- 0.51	0.039- 0.254	0.025- 0.227		

Using: Kruskal Wallis Test; p-value >0.05 NS; IQR: Interquartile range
Mann-Whitney test:
Comparison between low corneal astigmatism and with the rule high corneal astigmatism Comparison between low corneal astigmatism and against the rule high corneal astigmatism.
Comparison between with the rule high corneal astigmatism and against the rule high corneal astigmatism.

Group 2 RNFL was found thicker in mean average (3.16 μm), nasal (2.26 μm), and inferior (1.58 μm) quadrants. It was thinner in mean superior (-3.11 μm) and temporal (-0.37 μm) quadrants. All these difference values fail to be statistically significant, and were less than tolerance limit of inter-visit RNFL thickness measurement variability **(Table 3)**.

Table (3): Comparison between groups according to mean RNFL thickness

Groups / RNFL	Low corneal astigmatism (n=20)		(WTR) corneal astigmatism (n=10)		(ATR) corneal astigmatism (n=10)		ANOVA
	Mean	±SD	Mean	±SD	Mean	±SD	p-value
RNFL average	94.45	5.52	96.70	5.33	97.60	2.63	>0.05
RNFL superior	118.95	8.51	119.60	10.69	116.80	9.20	>0.05
RNFL nasal	82.35	4.87	84.20	6.21	84.50	4.14	>0.05
RNFL inferior	119.15	10.29	120.60	7.96	121.10	6.49	>0.05
RNFL temporal	72.8	5.04	72.40	6.50	71.60	4.84	>0.05

F-One Analysis of Variace;
Using Post Hoc test: Least Significant Difference (LSD),p-value>0.05 NS; *p-value <0.05 S

DISCUSSION

In this OCT optic nerve head study, difference values among the three groups failed to be significant regarding disc area, rim area, vertical C/D ratio, cup volume, average and quadrant RNFL thickness.

Hwang et al. (2012 -c) investigated the effect of astigmatism on OCT ONH measurement using soft toric contact lens on 30 eyes. They reported results of comparison of RNFL thickness between the baseline state and induced astigmatic states. After induction of the WTR astigmatism, RNFL thicknesses of average, superior, and inferior areas decreased. After induction of the ATR astigmatism, RNFLs thicknesses of average, nasal, and temporal areas decreased. Difference in results can be attributed to their larger study population and wider range of astigmatism. Another thing is that although they have noted their result to be statistically significant, they already admitted that such result fails to be clinically substantial, because OCT ONH can normally change measurements of same patient from visit to visit within an acceptable range.

Liu et al. (2012) denoted thinner RNFL thickness in the temporal quadrant in high corneal astigmatism group. They suggested that, with the rule astigmatism results in vertically oval image of the optic disc, and the scan circle was farther from the optic disc in the horizontal meridian. So, there is a tendency for the RNFL thickness in the temporal and nasal regions to become thinner, but there was contradiction in their result that thinning was noted by them only in the temporal quadrant, while the nasal quadrant was reported to be thicker.

Secondly, it has been reported in many studies that myopia (increased refractive power of the eye) is associated with thinner RNFL measurement by OCT. While *Liu et al. (2012)* reported WTR astigmatism (increased refractive power of the vertical meridian) to cause thinning in the horizontal quadrants (temporal and nasal) which is contradiction. Since the vertical meridian is supposed to exert effect upon vertical quadrants.

Other reported findings by *Liu et al. (2012)* about ONH parameters are larger disc area and larger rim area in high corneal astigmatism group; this can be attributed to large variation among normal population. Like our study, they noted no significant difference in the more important parameters including: average

cup-to-disk ratio, vertical cup-to-disk ratio and cup volume between the two groups.

CONCLUSION

Corneal astigmatism had statistically insignificant effect on optic nerve head parameters and retinal nerve fiber layer thickness measured with spectral domain optical coherence tomography.

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دراسة تأثيرلانقطية القرنية على قياسات سمك طبقة الألياف العصبية بالشبكية وقياسات رأس العصب البصرى بواسطة التصوير البصرى التوافقى المقطعى

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خلفيـــة البحـــث: التصـــوير البصـــرى التـــوافقى المقطعـــى يســـتطيع إلتقـــاط صـــورا لطبقـــات العـــين بطريقـــة غيـــر مُخترِقـــة، ويســـتخدم بشـــكل واســـع فـــى دراســـة طـــب وجراحـــة العيـــون للحصـــول علـــى صـــور عاليـــة الجـــوده لـــرأس العصـــب البصـــرى والماقولـــة، ويُعـــد قيـــاس ســـمك طبقـــة الألياف العصـــبية بالشـــبكية ورأس العصـــب البصـــرى ضـــروريا حيـــث أن هـــذه القياســـات تتـــأثر بالعديـــد مـــن الأمـــراض المختلفـــه بالعصـــب البصـــرى مثـــل الميـــاه الزرقـــاء، وضمور العصب البصرى، وإرتشاح العصب البصرى.

الهـــدف مـــن البحـــث: تقيـــيم تـــأثير لانقطيـــة القرنيـــة علـــى قيـــاس ســـمك طبقـــة الألياف العصـــبية بالشـــبكية ورأس العصـــب البصـــرى بواســـطة التصـــور البصرى التوافقى المقطعى.

المرضـــى و طـــرق البحـــث: أربعـــون عينـــا لاثنـــين وثلاثـــين مريضـــا تـــم إدراجهـــم فـــى هـــذه الدراســـة، وتـــم تقســـيمهم لمجمـــوعتين متســـاويتين؛ المجموعـــة الأولـــى لا نقطيـــة قرنيـــة منخفضـــة (لا تتعـــدى نصـــف الدرجـــة)، والمجموعـــة الثانيـــة: لا نقطيـــة قرنيـــة عاليـــة (تبـــدأ مـــن درجتـــين)، والثانيـــة تنقســـم إلـــى مجمـــوعتين فـــرعيتين متســـاويتين؛ لا نقطيـــة قرنيـــة مـــع القاعـــدة، وضـــد القاعـــدة. وقـــد تـــم فحـــص جميـــع المرضـــى فحصـــا شـــاملا مـــع إجـــراء تصـــوير تـــوافقى مقطعـــى لـــرأس العصـــب البصـــرى فـــى قســـم طـــب وجراحـــة

العين بكلية الطب جامعة الأزهر بالقاهرة و ذلك خلال الفترة من يناير وحتى نوفمبر عام 2019.

نتائج البحث: أوضحت نتيجة المقارنة عدم وجود فروق معتبرة بين المجموعتين فيما يخص قياسات العصب البصرى وسمك طبقة الألياف العصبية الشبكية.

الاستنتاج: عدم تأثر قياسات رأس العصب البصرى وسمك طبقة الألياف العصبية الشبكية بلانقطية القرنية.

الكلمات الدَّالة: لا نقطية، العصب البصرى، التصوير البصرى التوافقى المقطعى.