Print ISSN: 2321-6379
Online ISSN: 2321-595X

Original Article

Evaluation of Peripapillary Retinal Nerve Fiber Layer and Macular Thickness in Myopic Patients by Spectral Domain Optical Coherence Tomography

Yuvraj Hardia[1], Shubhra Mehta[2], Kshitiz Gupta[3], Manoj Mehta[4]

[1]Consultant, Advanced Eye Laser Surgery Centre, Rau, Indore, India, [2]Professor, R.D. Gardi Medical College, Ujjain, Madhya Pradesh, India, [3]Post Graduate, R.D. Gardi Medical College, Ujjain, Madhya Pradesh, India, [4]Professor and Head of the Department, R.D. Gardi Medical College, Ujjain, Madhya Pradesh, India

Abstract

Background: Myopia is a prevalent refractive error characterized by light focusing in front of the retina, with projections indicating that nearly 50% of the global population could be affected by 2050. Myopia-related changes in retinal structure, especially in the retinal nerve fiber layer (RNFL) and macula, are observable with Optical Coherence Tomography (OCT). This study aimed to assess RNFL and macular thickness variations across different grades of myopia (mild, moderate, and high) using spectral domain OCT.

Materials and Methodology: This prospective, observational study was conducted at the Ruxmaniben Deepchand Gardi Medical College, Ujjain, Madhya Pradesh, with a sample of 96 patients aged ≥15 years diagnosed with axial myopia. Participants were categorized into three groups based on spherical equivalent: Low (−1D–<−3D), moderate (−3D–<−6D), and high (≥−6D) myopia. Comprehensive ocular exams were performed, including visual acuity, non-cycloplegic and cycloplegic refractions, intraocular pressure measurements, and axial length assessment. RNFL and macular thickness were measured in four primary peripapillary sectors and twelve sub-quadrants using spectral domain optical coherence tomography, with all data systematically recorded and analyzed using Statistical Package for Social Sciences.

Results: The study found a significant correlation between myopia severity and RNFL thickness (P = 0.000), with increased myopia associated with progressive thinning in the temporal, superior, nasal, and inferior quadrants. In addition, macular measurements showed that higher myopia correlated with decreased inner and outer macular thickness and macular volume, though subfoveal thickness increased. These results indicate that axial myopia in young adults is associated with structural retinal changes, notably RNFL thinning and macular volume reduction.

Conclusion: This study confirms that higher degrees of myopia are associated with early structural changes in the retina, particularly in RNFL and macular thickness. Regular OCT monitoring may be crucial for early detection and differentiation of myopia-induced retinal changes from glaucoma, helping to inform clinical management and intervention strategies for progressive myopia cases.

Keywords: Myopia, Retinal nerve fiber layer, Macular thickness, Optical coherence tomography, Axial myopia, Retinal nerve fiber layer thinning

INTRODUCTION

Myopia (short-sightedness) is a common ocular condition where light rays focus in front of the retina instead of on it.[1] The condition's prevalence has been increasing dramatically, with projections suggesting that half of the world's population will be myopic by 2050.[2] In India, the overall prevalence is 34.6%, with no significant difference between urban and rural populations. This increase is largely attributed to increase near-task activities, such as computer work, video games, and smartphone use.[3]

Optical Coherence Tomography (OCT) is a non-invasive diagnostic tool that measures macular and retinal nerve fiber layer (RNFL) thickness.[4,5] Research has shown that myopia affects the size and shape of the optic disc and RNFL, with high myopia patients showing thinner average

Access this article online

www.ijss-sn.com

Month of Submission : 10-2024
Month of Peer Review : 11-2024
Month of Acceptance : 12-2024
Month of Publishing : 12-2024

Corresponding Author: Dr. Kshitiz Gupta, Room No. 215 RMO Hostel, R.D. Gardi Medical College, Ujjain-456006, Madhya Pradesh, India.

RNFL compared to those with low or moderate myopia.[6] This thinning is believed to result from the stretching of ocular layers during eyeball elongation and has been associated with reduced spatial resolution and narrower retinal arterioles.[7-9]

A significant concern with myopia is its relationship with glaucoma and the diagnostic challenges it presents. The changes in optic disc structure in myopic eyes can lead to erroneous glaucoma diagnoses, as RNFL thinning in myopia can be difficult to distinguish from glaucomatous RNFL thinning. This presents a risk of overdiagnosis and highlights the importance of careful evaluation using tools, such as OCT to measure RNFL and macular thickness in patients with varying degrees of axial myopia.[10-12]

MATERIALS AND METHODS

Ours was a prospective, observational study conducted at the Outpatient Department of Ophthalmology, Ruxmaniben Deepchand Gardi Medical College (RDGMC), Ujjain, Madhya Pradesh. The study included 96 patients with axial myopia, calculated using the formula: $n = z^2*P*(100–P)/d^2$, where z=1.96 at 95% confidence interval, P = 55% (prevalence of Low Myopia), and absolute error=10%.

Inclusion Criteria

The study included patients with best-corrected distance visual acuity ≥6/9 on Snellen's chart, >−1D spherical equivalent (SE) of axial myopia, age ≥15 years, normal intraocular pressure (≤21 mm Hg), and no retinal abnormalities apart from myopic peripapillary atrophy (PPA).

Exclusion Criteria

Patients were excluded if they had cataracts, diagnosed cases of glaucoma, previous kerato-refractive or intraocular surgery, diabetes or hypertension, strabismus/amblyopia, history of prior ocular trauma, neurological disease, vitreoretinal disease, or any ocular pathology other than refractive error.

Based on SE, patients were categorized into three groups. Group 1 included patients with low myopia (−1D–<−3D), Group 2 comprised patients with moderate myopia (−3D–<−6D), and Group 3 consisted of patients with high myopia (≥−6D).

The basic examination included recording of demographic data, comprehensive medical history, and chief complaints with duration. The ophthalmic examination consisted of visual acuity measurement using Snellen's chart for both UCVA and BCVA, non-cycloplegic refraction using Auto refractometer ARK-510A (Nidek) with an average of 5 readings, followed by cycloplegic refraction with cyclopentolate (1%). Additional examinations included slit lamp biomicroscopy, IOP measurement using non-contact tonometer CT 800, and axial length measurement using A-scan (PacScan 300A).

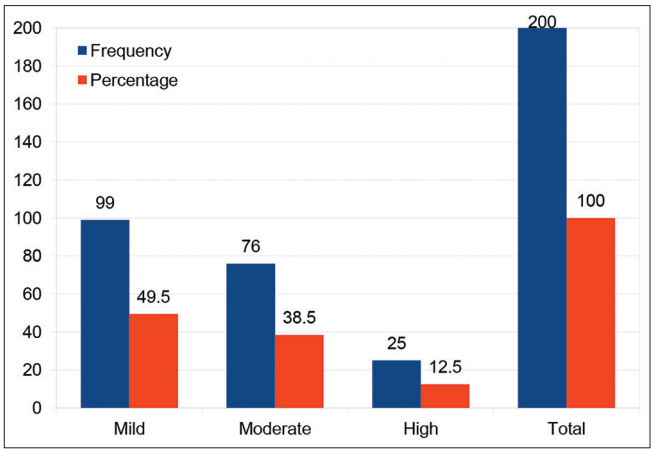

Figure 1: Distribution of myopic groups (*n* = 200)

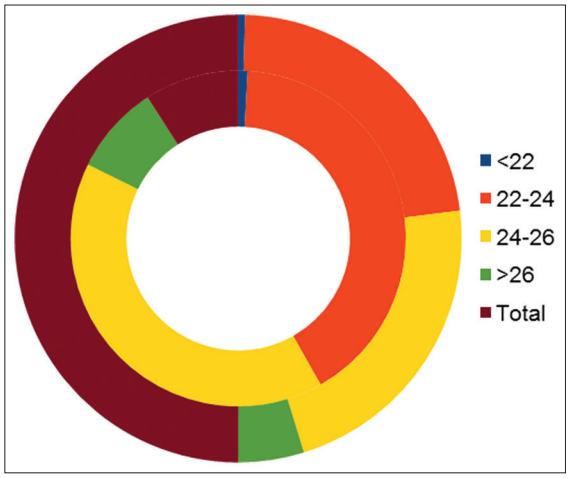

Figure 2: Distribution of various frequency of axial lengths amongst 200 eyes

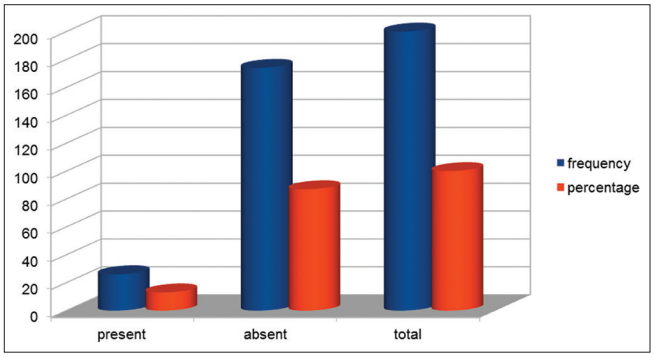

Figure 3: Distribution of perpapillary atrophy amongst the study group

Table 1: Comparison of mean of macular thicknesses with grade of myopia

Macular thicknesses	Myopic groups	Number	Mean±standard deviation. deviation	Minimum	Maximum	*P*-value
Subfoveal thickness (μm)	Mild	99	199.36±10.959	178	246	0.000
	Moderate	76	204.73±9.129	179	227	
	High	25	229.88±17.525	204	258	
	Total	200	205.27±14.848	178	258	
Temporal inner	Mild	99	294.05±13.533	248	312	0.000
	Moderate	76	283.09±12.418	242	315	
	High	25	258.68±9.664	242	280	
	Total	200	285.36±16.957	242	315	
Superior inner	Mild	99	308.25±11.475	278	332	0.000
	Moderate	76	289.17±31.046	173	336	
	High	25	258.04±38.006	173	289	
	Total	200	294.53±29.681	173	336	
Nasal inner	Mild	99	305.89±14.101	278	336	0.000
	Moderate	76	293.08±16.572	262	332	
	High	25	272.40±10.008	259	290	
	Total	200	296.71±18.296	259	336	
Inferior inner	Mild	99	303.52±17.771	239	328	0.000
	Moderate	76	291.35±17.115	253	329	
	High	25	270.08±14.514	245	287	
	Total	200	294.59±20.237	239	329	
Temporal outer	Mild	99	252.06±13.513	225	285	0.000
	Moderate	76	249.23±12.888	232	278	
	High	25	234.08±20.102	207	274	
	Total	200	248.71±15.283	207	285	
Superior outer	Mild	99	265.87±15.699	244	308	0.000
	Moderate	76	261.97±16.818	212	301	
	High	25	239.00±12.217	212	254	
	Total	200	260.99±17.862	212	308	
Nasal outer	Mild	99	284.62±15.871	258	322	0.000
	Moderate	76	276.63±19.728	232	320	
	High	25	250.80±11.199	232	272	
	Total	200	277.28±20.043	232	322	
Inferior outer	Mild	99	259.33±14.116	234	288	0.000
	Moderate	76	256.55±10.669	236	285	
	High	25	243.44±8.549	234	264	
	Total	200	256.26±13.201	234	288	

Table 2: Comparison of mean of retinal nerve fiber layer quadrants with grade of myopia

Quadrant	Myopic group	Number	Mean±standard deviation deviation	Minimum	Maximum	*P*-value
Temporal quadrant	Mild	99	71.69±8.520	56	89	0.000
	Moderate	76	71.37±8.429	51	90	
	High	25	60.04±8.493	47	80	
	Total	200	70.11±9.262	47	90	
Superior quadrant	Mild	99	128.78±13.839	103	150	0.000
	Moderate	76	126.56±13.283	109	160	
	High	25	106.96±11.066	88	123	
	Total	200	125.19±14.973	88	160	
Nasal quadrant	Mild	99	83.86±13.228	63	115	0.000
	Moderate	76	72.86±9.860	47	95	
	High	25	62.68±9.590	48	80	
	Total	200	76.92±13.730	47	115	
Inferior quadrant	Mild	99	132.74±13.516	101	155	0.000
	Moderate	76	123.03±11.822	109	182	
	High	25	107.04±8.309	97	118	
	Total	200	125.74±14.875	97	182	
Average RNFL thickness	Mild	99	103.77±7.570	86	118	0.000
	Moderate	76	97.72±4.723	87	109	
	High	25	82.76±4.719	75	92	
	Total	200	98.79±9.154	75	118	

OCT examination was performed using Topcon 3D OCT-1 Maestro, accepting only well-centered images with signal strength >8. RNFL measurements were taken in four main peripapillary sectors (Temporal, Superior, Nasal, Inferior) and twelve sub-quadrants. Macular measurements followed the ETDRS protocol, including fovea (1 mm diameter), inner macula (1–3 mm), outer macula (3–6 mm), with recordings of central foveal thickness, center point thickness, and macular volume.

All patient data were systematically recorded in pre-tested pro forma, including demographic information, clinical findings, and OCT measurements. Written informed consent was obtained from all participants, and patient confidentiality was maintained throughout the study.

Statistical Analysis

Data analysis was performed using Statistical Package for Social Sciences software, incorporating calculation of means and standard deviations, percentile analysis, and significance testing with *P*-value set at 0.05.

Ethical Considerations

The study maintained high ethical standards with written informed consent from all participants, maintenance of patient confidentiality, and no compromise in the quality of regular eye care. Regular follow-up was maintained regardless of study participation.

RESULTS

The study was a prospective, comparative, observational investigation conducted at RDGMC, Ujjain, examining 96 patients with axial myopia over 1 year. The patient demographics showed a mean age of 21.59 ± 5.207 years, with a female majority (63%). Most participants were students (71%), predominantly from urban areas (80%), and belonging to middle socioeconomic groups (85%). The socioeconomic background was predominantly middle-class (85%), with smaller representations from low (6%) and high (9%) socioeconomic groups. Educationally, most patients (60%) had completed secondary education, while significant portions (29%) were graduates.

Regarding visual acuity, the majority of eyes (56.5%) had unaided visual acuity between 3/60 and 6/60. With correction, 41% of eyes achieved 6/9 vision, while 59% achieved 6/6 vision. The study included 99 (49.5%) mild myopic eyes, 76 (38%) moderate myopic eyes, and 25(12.5%) high myopic eyes.

The axial length of the eyes—a key factor associated with myopia—mostly fell between 22.10 and 26 mm. No significant associations were found between myopia severity and variables such as age, sex, socioeconomic status (SES), occupation, education level, or urban/rural residence. Furthermore, PPA, a condition associated with high myopia, was present in 13% of the cases, highlighting a lower incidence within this population

A significant correlation was found between the grade of myopia and RNFL thickness ($P = 0.000$). As the SE increased, there was a corresponding decrease in inferior, temporal, nasal, and superior RNFL thickness. Similarly, the study demonstrated that average macular thickness, inner and outer macular thickness, and macular volume decreased with increasing SE, though notably, subfoveal thickness showed an increase.

The findings suggest that axial myopia in young adults is associated with early anatomical changes in the retina. The study observed that healthy young myopic eyes exhibited decreased macular thickness and lower macular volume correlating with longer axial length. These results indicate that structural retinal changes may occur early in the development of axial myopia [Figures 1-3 and Tables 1 and 2].

DISCUSSION

This study explored the effects of different grades of myopia on peripapillary RNFL and macular thickness using spectral domain optical coherence tomography (SD-OCT). Myopia has been linked with structural changes in the retina and RNFL, with the degree of myopia affecting the extent of these changes. Our study builds on prior research by focusing on three categories of myopia: mild (−1D–<−3D), moderate (−3D–<−6D), and high (>−6D).

The use of SD-OCT, which is considered a gold standard for retinal imaging, allowed for detailed measurements of RNFL and macular thickness. In line with prior studies, our findings confirm that increased myopia severity correlates with reduced RNFL and macular thickness, offering essential data for clinicians monitoring myopic patients.

Our study population predominantly consisted of younger individuals (mean age: 21.59 years), mostly between 15 and 30 years. This demographic focus is relevant, as younger individuals are at a critical stage for myopia progression, potentially due to lifestyle factors, prolonged close work, and reduced outdoor time.

Other studies, such as Song *et al.*, found similar age-independent correlations, (Three groups central subfield thicknesses were 244.56±12.19 μm, 254.33±11.61 μm, and 261.75±11.83 μm, respectively, with statistically

significant differences between two random groups) which suggests that structural retinal changes related to myopia occur regardless of age, though this area warrants further exploration with broader age groups.[13]

In terms of gender, our study did not find a statistically significant difference ($P = 0.106$) in RNFL thickness between male and female participants. This aligns with Alasil *et al*., who found no gender-related variation in RNFL thickness among myopic patients. These results imply that both sexes are equally susceptible to myopia-related retinal changes, suggesting that other factors such as genetics or lifestyle might play more significant roles in myopia progression.[14]

SES was another variable assessed, and our findings showed no significant association ($P = 0.973$) between SES and the degree of myopia. Given that myopia affects individuals across socioeconomic backgrounds; our findings indicate that myopia is more likely influenced by environmental and genetic factors rather than SES alone.

Occupation and education have been identified as potential risk factors for myopia, particularly in populations where prolonged near-work activities are prevalent. Studies like Joseph *et al*. found a higher prevalence of myopia among educated individuals, possibly due to increased indoor activities and limited outdoor exposure. In our study, however, no significant association was found between education or occupation and the degree of myopia, likely due to our young cohort where most participants were students, limiting occupational diversity.[15]

A notable finding in our study was the association between PPA and myopia severity. Our results indicate that high myopia patients had a higher prevalence of PPA compared to mild and moderate myopic individuals. This positive correlation is consistent with Liu *et al*. (They found that ONH linked with SE, age, and AL ($P < 0.01$), while PPA and peripapillary chorioretinal atrophy correlated with SE. ($P < 0.01$) 2017, who observed that PPA increased with axial length and myopia severity. The association between myopia and PPA highlights the potential for progressive myopia to impact optic nerve health, which may have clinical implications for glaucoma risk in highly myopic patients.[16]

Axial length, a critical factor in myopia progression, also showed a significant positive correlation with myopia severity. The increase in axial length with higher degrees of myopia aligns with findings by Samuel and Krishnagopal (The mean axial length of high myopia (26.7 ± 0.97 mm) was significantly higher compared to moderate (24.6 ± 0.81 mm) and low myopia (23.5 ± 0.81 mm) with a *P*-value of $P = 0.001$.) (2015), supporting the hypothesis that axial elongation is a primary contributor to retinal stretching and thinning. Monitoring axial length is therefore important in understanding the structural adaptations occurring in high myopia, which may inform preventive strategies.[17]

Our study observed significant thinning of RNFL with increasing myopia, particularly in the high myopia group, where mean RNFL thickness was considerably lower compared to the mild and moderate groups. This finding concurs with the research by Tai *et al*. and Lim and Chun ($P < 0.05$), which reported similar RNFL thinning in high myopic eyes. The progressive RNFL thinning with increased myopia underscores the importance of early intervention to prevent further deterioration in highly myopic patients.[18,19]

The assessment of macular thickness and volume also revealed a clear trend: Increased myopia was associated with decreased macular thickness in both inner and outer regions, except for subfoveal thickness, which increased with higher myopia. This finding aligns with Zereid and Osuagwu and Song *et al*. (Three groups central subfield thicknesses were 244.56 ± 12.19 μm, 254.33 ± 11.61 μm, and261.75 ± 11.83μm, respectively, with statistically significant differences), who reported thinner retinal thickness in myopic eyes in non-foveal regions. The increase in subfoveal thickness with myopia might reflect mechanical stretching of the retina, particularly in the periphery.[20,13]

Comparative analysis with studies such as Chen *et al*. (2008) supports our observation of macular volume reduction with increasing myopia. As macular volume and thickness decrease, it is likely that the larger axial length in myopic eyes causes panretinal thinning and stretching, except for the central foveal area, which appears elevated. This trend indicates structural changes specifically in the macula due to the elongation of the eye.

Finally, our study's findings emphasize the importance of regular OCT monitoring in myopic patients, especially those with moderate to high myopia. By documenting RNFL and macular thickness changes, OCT can help clinicians detect early structural changes that may predispose individuals to complications. The strong correlation between myopia progression and retinal changes observed in our study highlights the need for vigilance in managing high myopia cases.

CONCLUSION

This study corroborates prior research on the association between myopia severity and thinning of the RNFL and

macula, particularly in high myopia. Given the growing prevalence of myopia globally, these findings underscore the value of OCT as a diagnostic tool for tracking myopia-related retinal changes and guiding clinical management.

REFERENCES

1. Sihota R, Tandon R. In: Miller PJ, editor. Parson's Diseases of the Eye. 21st ed. New Delhi, Edinburgh: Elsevier, Churchill Livingstone;2011.
2. Holden BA, Fricke TR, Wilson DA, Jong M, Naidoo KS, Sankaridurg P, *et al*. Global prevalence of myopia and high myopia and temporal trends from 2000 through 2050. Ophthalmology 2016;123:1036-42.
3. Saxena R, Vashist P, Menon V. Is myopia a public health problem in India? Indian J Community Med 2013;38:83-5.
4. Huang D, Swanson EA, Lin CP, Schuman JS, Stinson WG, Chang W, *et al*. Optical coherence tomography. Science 1991;254:1178-81.
5. Reiderer SJ. Current technical development of magnetic resonance imaging. IEEE Eng Med Biol Mag 2000;19:34-1.
6. Sezgin Akcay BI, Gunay BO, Kardes E, Unlu C, Ergin A. Evaluation of the ganglion cell complex and retinal nerve fiber layer in low, moderate, and high myopia: A study by RTVue spectral domain optical coherence tomography. Samin Ophthalmol 2017;32:682-8.
7. Yanoff M, Fine BS. Ocular Pathology: A Text and Atlas. Philadelphia, PA: Harper and ROW; 1982.
8. Gopinath B, Wang JJ, Kifley A, Tan AG, Wong TY, Mitchell P. The association between ocular biometry and retinal vascular caliber is comparable from early childhood to adolescence. Invest Ophthalmol Vis Sci 2013;54:1501-8.
9. Tai EL, Li LJ, Wan-Hazabbah WH, Wong TY, Shatriah I. Effect of axial eye length on retinal vessel parameters in 6 to 12-year-old malay girls. PLoS one 2017;12:e0170014.
10. Wong TY, Klein BE, Klein R, Knudston M, Lee KE. Refractive errors, intraocular pressure, and glaucoma in a white population. Ophthalmology 2003;110:211-7.
11. Kim YW, Lee EJ, Kin TW, Kim M, Kim H. Microstructure of β-zone parapapillary atrophy and rate of retinal nerve fiber layer thinning in primary open-angle glaucoma. Ophthalmology 2014;121:1341-9.
12. Mitchell P, Hourihan F, Sandbach J, Wang JJ. The relationship between glaucoma and myopia: The blue mountains eye study. Ophthalmology 1999;106:2010-5.
13. Song AP, Wu XY, Wang JR, Liu W, Sun Y, Yu T. Measurement of retinal thickness in macular region of high myopic eyes using spectral domain OCT. Int J Ophthalmol 2014;7:122-7.
14. Alasil T, Wang K, Keane PA, Lee H, Baniasadi N, de Boer JF, *et al*. Analysis of normal retinal nerve fiber layer thickness by age, sex, and race using spectral domain optical coherence tomography. J Glaucoma 2013;22:532-41.
15. Joseph S, Krishnan T, Ravindran RD, Maraini G, Camparini M, Chakravarthy U, *et al*. Prevalence and risk factors for myopia and other refractive errors in an adult population in southern India. Ophthalmic Physiol Opt 2018;38:346-58.
16. Liu W, Gong L, Li Y, Zhu X, Stewart JM, Wang C. Peripapillary atrophy in high myopia. Curr Eye Res 2017;42:1308-12.
17. Samuel NE, Krishnagopal S. Foveal and macular thickness evaluation by spectral OCT SLO and its relation with axial length in various degree of myopia. J Clin Diagn Res 2015;9:NC01-4.
18. Tai EL, Ling JL, Gan EH, Adil H, Wan-Hazabbah WH. Comparison of peripapillary retinal nerve fiber layer thickness between myopia severity groups and controls. Int J Ophthalmol 2018;11:274-8.
19. Lim HT, Chun BY. Comparison of OCT measurements between high myopic and low myopic children. Optom Vis Sci 2013;90:1473-8.
20. Zereid FM, Osuagwu UL. Myopia and regional variations in retinal thickness in healthy eyes. J Ophthalmic Vis Res 2020;15:178-86.

How to cite this article: Hardia Y, Mehta S, Gupta K, Mehta M. Evaluation of Peripapillary Retinal Nerve Fiber Layer and Macular Thickness in Myopic Patients by Spectral Domain Optical Coherence Tomography. Int J Sci Stud 2024;12(9):29-34.

Source of Support: Nil, **Conflicts of Interest:** None declared.