Refractive and Binocular Vision Status and Associated Asthenopia among Clinical Microscopists

Kaiti R, Shrestha JB, Dev MK, Pradhan A

Consultant Optometrist

Nepal Eye Hospital,

Kathmandu, Nepal.

Corresponding Author

Raju Kaiti

Consultant Optometrist,

Nepal Eye Hospital,

Kathmandu, Nepal.

E-mail: rajukaiti@gmail.com

Citation

Kaiti R, Shrestha JB, Dev MK, Pradhan A. Refractive and Binocular Vision Status and Associated Asthenopia among Clinical Microscopists. *Kathmandu Univ Med J.* 2022; 2022;80(4):499-504.

ABSTRACT

Background

Clinical microscopists are at a greater risk of developing binocular vision anomalies and asthenopia.

Objective

To assess the refractive and binocular vision status and to explore the association between the presence of asthenopic symptoms and microscopy work among clinical microscopists working at medical laboratory department.

Method

This cross-sectional study involved 37 clinical microscopists working at medical laboratory department of Dhulikhel Hospital, Nepal. The study was conducted from January to December 2013. Only those participants who had been using microscope for at least a year were enrolled in this study. Each participant underwent distance visual acuity (VA) assessment, refractions, and orthoptic evaluation, including measurement of distance and near phoria, near point of convergence (NPC), near point of accommodation (NPA), positive fusional vergence (PFV), adduction, and calculation of accommodation convergence/accommodation (AC/A) ratio. The tear test was also carried out in each subject. Information about use of glasses, microscopy work (duration, and time spent per day in microscope), and visual symptoms associated with the use of microscope such as eye strain, headache, double vision, and near vision were collected.

Result

The mean age of the clinical microscopists was 29 ± 5.7 years. The prevalence of refractive error was 56.76% and the mean spherical equivalent (SE) refractive error was -0.77 ± 0.86 D. Refractive error had neither correlation with microscopy work and asthenopic symptoms associated with it, and nor with binocular vision parameters-NPC, AA and AC/A ratio. However, there was a positive association between asthenopic symptoms and microscopy work. There was statistically significant difference between symptomatic and asymptomatic subjects for binocular vision parameters, including NPC, AA and positive fusional vergence (PFV) for near.

Conclusion

Microscopy work has an impact on near binocular vision. Asthenopic symptoms bear a positive association with microscopy work. Refractive error has no significant correlation with either microscopy works or associated asthenopic symptoms.

KEY WORDS

Asthenopia, Binocular vision, Microscopists, Orthoptic, Refractive error

INTRODUCTION

The prevalence of myopia is substantially higher among microscopists than observed in the general population.[1,2] Desk workers, microscope users and visual display operators who are involved with extensive near work have greater chances of developing myopia compared to the general population.[3-12] These occupations are correlated with ocular and visual morbidities which range from myopia, accommodative insufficiency, vergence dysfunctions and heterophoria.

The closer the working distance, the greater is the accommodation required and this leads to myopia progression.[13-21] Microscopy can be considered as a form of the near visual task.[2,8] Although the microscope's task is projected at infinity, microscopists tend to accommodate when using microscopes. The excessive accommodation that is induced by such equipment is called instrument myopia.[1-3,6-10] An elevated AC/A ratio may play a role in environmentally induced myopia.[2,20]

The prevalence of binocular vision anomalies, which includes convergence insufficiency (CI), accommodative insufficiency (AI) and decreased PFV, is higher in people who have long term near work.[13,14] Microscopists have an increased risk of developing binocular vision anomalies and asthenopic symptoms.[2,15] Difficulty in accommodation and convergence of eye can result in fatigue, eye strain, and visual discomfort in microscope users.

Regular use of microscope affects visual systems. More than 90% of participants have reported some form of visual problems associated with microscopy work. Headache, stress due to long working hours and anxiety during or after microscope use have also been reported previously.[22,23]

There is very little information about the refractive and binocular status among clinical microscopists, and asthenopic symptoms associated with microscopy work. The purpose of this study was to assess the refractive status and the binocular vision anomalies among clinical microscopists and to determine their association with asthenopic symptoms among those microscopists. The study would form a baseline data for future longitudinal study.

METHODS

This cross-sectional descriptive, and hospital based study involved 37 microscopists working at medical laboratory department of Dhulikhel Hospital, Nepal. The study was conducted from January to December 2013. Only those participants who had been using microscope for at least a year were enrolled in this study. Subjects with any history of chronic systemic diseases linked to ocular and visual morbidity e.g. diabetes mellitus, hypertension etc. were excluded from the study.

The institutional review board at the Kathmandu University School of Medical Sciences approved the study protocol, and the study followed the tenets of the Declaration of Helsinki. For the enrollees of this study, informed consent was gained from staff working in the medical laboratory department. Enrollees' particulars, including age, sex, and educational status, were noted.

Information about use of glasses, microscopy work duration, working hours per day in microscope, and visual symptoms experienced with use of microscope such as eye strain, headache, double vision, and blurred near vision were collected with the help of a questionnaire (Annex) completed by the subjects under the guidance of the examiners, who were the authors themselves. The questionnaire was based on the study by Ting et al.[2] However, we excluded blurred distance vision symptom questionnaire from those questionnaires because distance blur would be common without adequate refractive error correctional and our study was only cross-sectional. Symptoms were assessed on a four-point scale from 0 to 4 as: not at all (0), sometimes (1), often (2), or all the time (3). The mean symptom scores of each visual symptoms reported by microscopists were obtained by averaging the score of each participants. On the basis of these visual symptoms, microscopists were divided into two groups-symptomatic and asymptomatic. Participant who responded with any of above visual symptoms, either often or all the time, were included in symptomatic group and the rest in asymptomatic group.

Presenting distance VA was assessed with the Snellen chart at a 6-m distance. Quantification of distance VA was expressed in the Snellen fraction and recorded as 6/6, 6/9 and 6/12. Dioptric values of present glasses prescriptions were noted. Refractions were performed in all participants by an optometrist. We also performed cycloplegic refractions in 3 subjects because fluctuating error, scissor or irregular reflex was found in the eyes during retinoscopy. The final refractive error under cycloplegic refraction was recorded after deducting +0.75 D attributed to cycloplegic effect.

Refractive error was classified was emmetropia, myopia and hyperopia based on the definition of the prior studies.[1,2] Refractive errors of spherical equivalent (SE) of -0.25 to +0.75 D were classified as emmetropic. Myopia was defined as SE of -0.50 D and greater and hyperopia was defined as SE of +0.75 D and greater in magnitude.

Orthoptic examinations were done, which entailed measurement of distance and near phoria, NPC, AA, PFV and adduction. Distance and near phoria was measured by cover test and prism cover test at a distance of 6-m and 0.4-m respectively. An exophoria of 1 or 2 ΔD was considered normal. NPC and AA were measured in cm unit by the Royal Army Force (RAF) rule. The RAF rule consists of a 50 cm long rule with a slider holding a rotating four-sided cube, each side having different target. Participants were

asked to watch a dot target in the cube binocularly and the cube was steadily moved towards them until a dot was noticed double. This distance was record as a subjective convergence. For measuring AA, participants were asked to read the text target in the cube uniocularly and the cube was moved slowly until letters were reported blur. This distance was recorded as AA. PFV was measured by prism bar in prism diopter (ΔD) base out (BO).[24] Adduction was measured in degree by synoptophore. AC/A ratio was calculated by gradient method. All examination was performed by same optometrists who were researcher themselves to minimize inter-observer differences.

Schirmer's II tear test and tear film break up time (TBUT) test were done in all participants. Schirmer's II was assessed by measuring Whatman filter strip, 4 minutes after instillation of 4% xylocaine and the TBUT was measured using sodium fluorescein and slit lamp observation measured using sodium fluorescein and slit lamp observation. The examiner performing tear test was blinded as to who had symptoms and who did not, in order to avoid a risk of bias in this data collection.

Recorded data were analyzed by Statistical Package for Social Sciences (SPSS) version 21.0 and Microsoft Excel version 2010. Appropriate statistical tools were implemented depending upon the distribution of the variables. Comparisons of age, NPC, AA, AC/A ratio, fusional vergence between symptomatic and asymptomatic groups were made using unpaired t-tests. The correlations were calculated between refractive error and working history and between refractive error and daily microscope use. ANOVA was applied to find correlation between refractive error with NPC, AA and AC/A ratio.

Table 1. Demographics of the study enrollees

Characteristics	Participants	CT for Near, N (%)		CT for Distance, N (%)	
Age Range (years)	Total, N (%) 37(100)	Orthophoria 17 (45.95%)	Heterophoria 20 (54.05%)	Orthophoria 25 (67.57%)	Heterophoria 12 (32.43%)
20-24	11(29.74)	7(41.19)	4(20.00)	7(28.00)	4(33.33)
25-29	10(27.02)	2(11.76)	8(40.00)	6(24.00)	4(33.33)
30-34	8(21.62)	2(11.76)	6(30.00)	5(20.00)	3(25.00)
35-39	8(21.62)	6(35.29)	2(10.00)	7(28.00)	1(8.34)
Gender					
Male	17(45.95)	8(47.06)	9(45.00)	11(44.00)	6(50.00)
Female	20(54.05)	9(52.94)	11(55.00)	14(56.00)	6(50.00)
Education					
PCL	21(56.76)	10(58.82)	11(55.00)	13(52.00)	8(66.67)
Bachelor	11(29.73)	6(35.29)	5(25.00)	8(32.00)	3(25.00)
Masters	5(13.51)	1(5.89)	4(20.00)	4(16.00)	1(8.33)

CT: Cover Test; PCL: Proficiency certificate level
Note: The percentage values in parentheses are by considering numbers in each subgroup as 100%.

Table 2. Presenting and best corrected distance VA of microscopists

VA (Snellen Notation)	Presenting N (%)	After correction N (%)
6/6	46(62.20)	74(100)
6/9	24(32.40)	-
6/12	4(5.40)	-
Total	74(100.0)	74(100)

VA: Visual Acuity
Note: VA was counted as 74 eyes of 37 subjects

RESULTS

Table 1 presents demographic characteristics. The mean age of the total 37 subjects using microscopes was 29.00 ± 5.75 years (range, 20-38 years). Twenty (54.05 %) were female and the remaining were male. There was statistically significant difference between the mean age of male (32.06 ± 5.9 years) and female clinical microscopists (26.40 ± 4.1 years) (independent t-test, p=0.002). We grouped our subjects into four categories as 20-24, 25-29, 30-34, and 35-39 years (Table 1).

Visual and refractive status of the clinical microscopists

Among 74 eyes of 37 microscopists, the presenting VA was 6/6 in 46 eyes (62.16%) of microscopists and the remaining 28 eyes (37.84%) had VA less than 6/6 (Table 2). Among the decreased VA, only 5 (13.51%) participants wore optical correction: 4 wore spectacles, 1 wore contact lenses.

All the subjects recruited in this study were using binocular microscopes with the image projected to optical infinity. The prevalence of refractive error in this group of clinical microscopists was 21(56.76%) and all subjects were myopic. In another words, the prevalence of myopia was 56.76%. The mean spherical equivalent refractive error was -0.77 ± 0.86 D (range, +0.25 to -4.50 D).

Association of refractive error with microscopy work

The mean duration of working as microscopists was 5.08 ± 2.99 years (range, 1 to 12 years). They spent 1 to 8 hours per day using a microscope, with an average time 4.34 ± 1.50 hours per day. There was no statistically significant association between the number of years working as microscopists and refractive error (r = 0.09, p=0.056, t-test). Similarly, there was no correlation between daily working hours per day and refractive error (r = 0.17, p= 0.312, t-test).

Binocular vision status of microscopists

Among 37 microscopists, 17(45.95%) were orthophoric and 20(54.05%) were heterophoric (Exophoria=19, and Intermittent exotropia=1) for near target; and 25(67.57%) microscopists were orthophoric and 12(32.43%) were heterophoric (Exophoria=10, and Intermittent exotropia =2) for distance target (Table 1). No cases of eso-deviation found in our study.

The mean values of NPC, AA, PFV for near, PFV for distance, and AC/A ratio were 9.81 ± 3.13cm (range, 7-25 cm), 9.42 ± 1.18 cm (range, 6-12 cm) for each eye, 16.13 ± 6.97ΔD (range, 6-40 ΔD), 11.38 ± 6.11ΔD (range, 4-40 ΔD) and 5.34 ± 1.09 (range 2.40-6.40) respectively (Table 3). The NPC (ANOVA, F= 0.671, p=0.721), AA (ANOVA, F= 0.673, p=0.582) and AC/A ratio (ANOVA, F= 1.338, p=0.271) had no correlations with refractive error.

Association of asthenopic symptom with binocular vision status

Among all microscopists, asthenopic symptoms were present in 51.35% and the remaining 48.65% were asymptomatic. Asthenopic symptoms were most common (24.32%) in the age group 20-24 years and the least (8.11%) in the age group 30-34 years whereas the age group 35-39 years had no asthenopic symptom at all. There was no association between asthenopic symptoms and age group (χ^2 = 11.10, df = 4, p=0.058) as well as asthenopic symptoms and gender (χ^2 = 3.11, df=1, p=0.065).

Although NPC, AA and PFV for near were statistically significant between symptomatic and asymptomatic subjects, but there was no statistically significant difference of PFV for distance, adduction, AC/A ratio and refractive error between the two groups (ANOVA, Table 3).

Table 3. Parameters of binocular vision status of microscopists

Characteristics (Units)	Mean±SD 37(100)	Symptomatic N (%), 19 (51.35)	Asymptomatic N (%), 18 (48.65)	p value
NPC (cm)	9.81±3.13	10.89±2.218	8.72±4.03	0.047*
NPA (cm)	9.42±1.18	10.27±1.318	8.55±1.01	0.001*
PFV for near (ΔD)	16.13±6.97	14.10±3.01	18.18±8.00	0.038*
PFV for distance (ΔD)	11.38±6.11	11.26±3.28	11.52±8.35	0.899
Adduction (degree)	11.49±4.48	10.82±5.29	12.10±4.54	0.440
AC/A ratio	5.34±1.09	5.23±1.01	5.46±1.19	0.541
Refractive error (DS)	-0.77±0.86	-0.82±0.68	-0.70±1.03	0.101

Asthenopic symptoms scores

Asthenopic symptoms such as eye strain, headache, double vision, and blurred near vision were significantly associated with the use of microscopes (Table 4).

Table 4. Reported scores for symptoms

Characteristics	Mean score ± SD	Prevalence (%)	P value
Eye strain	1.43 ± 0.64	51.3	0.000
Blur distance vision	0.63 ± 0.73	5.4	0.000
Blur near vision	0.23 ± 0.49	13.51	0.009
Headache	1.14 ± 0.85	40.5	0.000
Double vision	0.17 ± 0.38	12.1	0.012

Note: Scores were analyzed in term of status of subjects (scores scale: 0= none, 1= sometimes, 2= often, 3= always).

Dry eyes in microscopists

The prevalence of dry eyes was 42.73%, considering the value of Schirmer's-II less than 10 millimeter in 5 minutes and TBUT value less than 10 seconds. The mean values of Schirmer's II test and TBUT were 8.14 ± 5.83 millimeter and 5.80 ± 2.88 seconds which indicated dry eyes in our participants. Both the TBUT (r =0.59, p=0.00) and Schirmer's-II (r=0.54, p=0.001) tear tests were significantly associated with asthenopic symptoms.

DISCUSSION

This cross-sectional study involving 37 subjects was undertaken to determine the refractive and binocular status of clinical microscopists working at a laboratory department and to explore the asthenopic symptoms associated with microscopy work.

The prevalence of refractive error in this group of microscopists was 56.76% which was nearly similar to 60.0% as reported by Jain and Shetty's study but lower than 71% as reported by Adams and McBrian's study.[1,22] However, only 13.51% wore refractive correction in our study. The reason was due to the fact that 62.20% of the participants had a normal VA of 6/6 (Table 2). The majority of our subjects having normal VA of 6/6, had an insignificant magnitude of refractive error which did not deteriorate vision much and thus did not wear any optical correction. As would be expected, it could be due that insignificant magnitude of myopia that would have been induced during extensive near work like microscopy work. This could be due to reason that the accommodative insufficiency during near visual task would have played a role in myopia progression, which has been well documented in various studies.[1-3,5,6,9,10,13-16,21] Korniushina has also reported that long strain of accommodation system leads to professional myopia in microscope users. For this, this study directs a longitudinal study and with a larger sample size in the near future.[25]

Both the mean spherical equivalent and the prevalence of myopia, in our subjects were much lower than the Hong Kong Chinese microscopists.[2] The reason could be that the Hong Kong Chinese people are more susceptible to the myopia-producing effects of microscopy work than those in Nepalese. However, in our study, there was no correlation between refractive error and duration of working hours as microscopists or numbers of working hours per day. This was consistent with the study be Tings et al.[2]

There was no association between refractive error and NPC, or AA, or AC/A ratio in this study. In contrast to our study, Ting et al.'s and Jiang and Morse's studies showed that AC/A ratio played a role in environmentally induced myopia.[2,20] Therefore, to clearly show the relationship between AC/A ratio and myopia progression, a longitudinal

study should be conducted.[2]

All reported asthenopic symptoms such as eye strain, headache, double vision, and blurred near vision were highly prevalent in our study (Table 4). This finding was analogous to the studies by Adams et al. and Ting et al.[1,2] Among all asthenopic symptoms, eye strain or eye fatigue was the most common symptoms of all which was similar to the studies by Ting et al. and Jain et al.[2,22] It could also be due to decrease in blinking rate while performing microscopy work, which might cause dry eyes among those microscopists. The prevalence of dry eyes in this study was 42.73% which is approximately more than three times higher than 12.8% as reported by Jain et al. study.[22] The values of both the Schirmer's II test and TBUT were below the baseline normal value in our study and was significantly associated with asthenopic symptoms. Similar to Adams et al. and Ting et al. studies, refractive error was not correlated with asthenopic symptoms in our study.[1,2] It could be due to small number of participants in our study. It is therefore, another area of useful investigation to elucidate the linking relationship between myopia progression and asthenopic symptoms associated with microscope use, with large number of participants.

This study points out that PVF for near, NPC, and AA may be a good indicator for evaluation of binocular vision anomalies. There was statistically significant difference in PVF for near, NPC, and AA among symptomatic and asymptomatic group of microscopists and this was consistent with Moghaddam et al. study.[15] In contrary to this, AC/A ratio was not correlated with asthenopic symptoms in our study and this was in accordance with Moghaddam et al. study.[15]

The study has some limitations. One of the major limitations is that sample size of the study participants was not large enough. Another limitation could be that we did not investigate the presence of astigmatism and anisometropia among microscopists which could also affect asthenopic symptoms among those participants. Another concern could be that we did not classify our participants according to working hours per day. It is possible that those with longer working hours could be more symptomatic and those with shorter hours.

It is an unequivocal that asthenopic symptoms, diminished vision, significant uncorrected refractive errors, color vision deficiencies as well as anterior and posterior segment diseases interfere with efficient laboratory diagnosis and work performance. Any morbidity in visual function has a direct impact on overall performance of the persons using microscopes for a long time. The outcomes of this study are expected to increase the awareness about the visual and binocular anomalies among this population.

CONCLUSION

Microscopy work bears a positive correlation with near binocular vision anomalies and asthenopic symptoms associated with it. Refractive error has no significant correlation with either microscopy works or associated asthenopic symptoms. This project might be considered a pilot study, useful for helping to plan a more carefully designed longitudinal study that will allow more solid conclusions.

It is recommended that all clinical microscopists need to undergo ocular examinations including refraction, and orthoptic test; in case of having any asthenopic symptoms. Future research should be directed at finding relationship between myopia progression and microscope uses, symptoms, and AC/A ratio, with larger numbers of participants.

ACKNOWLEDGEMENTS

We would like to thank all the staffs working in Ophthalmology Department of Dhulikhel hospital for the assistance and support throughout the project. We are very much thankful to all the staffs of lab department for their active participation in this project.

REFERENCES

1. Adams DW, McBrien NA. Prevalence of myopia and myopic progression in a population of clinical microscopists. *Optom Vis Sci.* 1992; 69:467-73.
2. Ting P WK, Lam CS, Edwards MH, Schmid KL. Prevalence of myopia in a group of Hong Kong microscopists. *Optom Vis Sci.* 2004; 81:88-93.
3. Pandian A, Sankaridurg PR, Naduvilath T, Leary D, Sweeney DF, Rose K, et al. Accommodative facility in eyes with and without Myopia. *Invest Ophthalmol Vis Sci.* 2006; 47:4725-31.
4. Ting PWK, Schmid KL, Lam CSY, Edwards MH. Objective real-time measurement of instrument myopia in microscopists under different viewing conditions. *Vision Research*. 2006; 46: 2354-62.
5. Cuiffreda KJ, Lee M. Differential refractive susceptibility to sustained near work. *Ophthalmic Physiol Opt*. 2002; 22:372-9.
6. Wolffsohn JS, Sheppard AL, Vakani S, Davies LN. Accommodative amplitude required for sustained near work. *Ophthalmic Physiol Opt.* 2011; 31: 480-6.
7. Parssinen TO. Relation between refraction, education, occupation, and age among 26- and 46-year-old Finns. *Am J Optom Physiol Opt.* 1987; 64:136-43.
8. Wong TY, Foster PJ, Johnson GJ, Seah SK. Education, socioeconomic status, and ocular dimensions in Chinese adults: the Tanjong Pagar survey. *Br J Ophthalmol*. 2002; 86:963-8.
9. Nyman KG. Occupational near-work myopia. *Acta Ophthalmol Suppl.* 1988; 185:167-71.
10. Simensen B, Thorud LO. Adult-onset myopia and occupation. *Acta Ophthalmol (Copenh)* 1994; 72:469-71.
11. Wensor M, McCarty CA, Taylor HR. Prevalence and risk factors of myopia in Victoria, Australia. *Arch Ophthalmol.* 1999; 117:658-63.
12. Shimizu N, Nomura H, Ando F, Niino N, Miyake Y, Shimokata H. Refractive errors and factors associated with myopia in an adult Japanese population. *Jpn J Ophthalmol.* 2003; 47:6-12.

13. Wolffsohn JS, Sheppard AL, Vakani S, Davies LN. Accommodative amplitude required for sustained near work. *Ophthalmic Physiol Opt*. 2011; 31: 480-6.

14. Rosenfield M, Ciuffreda KJ, Hung GK. The linearity of proximally induced accommodation and vergence. *Invest Ophthalmol Vis Sci.* 1991; 32:2985-91.

15. Moghaddam HM, Ansari H, Nozari V, Bani LS. Evaluation of near binocular vision in symptomatic and asymptomatic microscopists. *JBUMS.* 2008; 10(5): 54-61.

16. Schober HAW, Dehler H, Kassel R. Accommodation during observations with optical instruments. *J Opt Soc Am*. 1970; 60:103-7.

17. Gwaiazda J, Thorn F, Bauer J, Held R. Myopic children show insufficient accommodative response to blur. *Invest Ophthalmol Vis Sci.* 1993; 34; 690-4.

18. McBrien NA, Adams DW. A longitudinal investigation of adult-onset and adult-progression of myopia in an occupational group. Refractive and biometric findings. *Invest Ophthalmol Vis Sci*. 1997; 38:321-33.

19. Bullimore MA, Jones LA, Moeschberger ML, Zadnik K, Payor RE. A retrospective study of myopia progression in adult contact lens wearers. *Invest Ophthalmol Vis Sci.* 2002; 43:2110-3.

20. Jiang BC, Morse SE. Oculomotor functions and late-onset myopia. *Ophthalmic Physiol Opt*. 1999; 19:165-72.

21. McBrien NA, Milllodot M. The relationship between tonic accommodation and refractive error. *Invest Ophthalmol Vis Sci.* 1987; 28:997-1004.

22. Jain G, Shetty P. Occupational concerns associated with regular use of microscope. *Int J Occup Med Environ Health.* 2014; 27(4):591-8.

23. Kreczy A, Kofler M, Gschwendtner A. Underestimated health hazard: proposal for an ergonomic microscope workstation. *Lancet*. 1999 Nov 13; 354(9191):1701-2.

24. Grosvenor T. Primary care optometry. 3rd ed.: Butterworth-Heinemann; 1996.

25. Korniushina TA. Physiological mechanisms of the etiology of visual fatigue during work involving visual stress. *Vestn Oftalmol.* 2000; 116(4): 33-6.