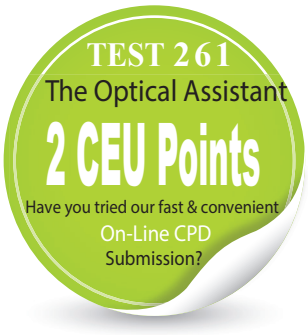
What Happens to Myopia during Presbyopia?



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Introduction

Seeing older myopic patients [older than 50 years] for the first time I often find the glasses that they are wearing to be over-minus by as much as -1.50 dioptres. This prompted me to find an explanation for this trend. Is it a case of a poor refraction or are we seeing a reduction in myopia since their previous visual examination? Furthermore, I have experienced a +1,25 shift in my own refractive error during my presbyopic years and hence this article.

Studying the literature, I found several studies reporting a decline in the prevalence of myopia in older adults. As far back as the 1980s and 1990s several studies in the USA reported on this phenomenon and it is therefore surprising to find a significant number of optometrists acknowledging to me that they are unaware of this. The obvious question is: why is this happening? Trying to find an answer to this showed that several studies reporting on age related changes in myopia during the presbyopic years produced contradictory results. It is important to identify and understand the potential factors underlying these changes, particularly if they relate to pathological causes, to allow us to understand the future health care needs of our aging population.

Population based studies

Possible visual impairment and the future management thereof has been the driving force behind many of the population-based studies. Uncorrected refractive errors are still considered to be the main cause of visual impairment across the globe [1]. Bomotti et al. (2018) [2] quote other studies showing that an estimated 153 million people worldwide are visually impaired as a result of uncorrected refractive errors and almost two thirds of these people are over the age of 50 years.

The three studies that are referred to most are the Beaver Dam study [3], The Baltimore study [4] and the Framingham Offspring Eye study [5]. The original data for the Beaver Dam study was collected during the late 1980s and the results show a decline in the prevalence of myopia with age. Myopia was found to be present in 42, 9% of presbyopes between the ages of 43 and 54 years and this declined to only 14,0% in people 75 years and older. The Baltimore study, done at almost the same time, focussed on an adult inner-city population and found a similar trend across gender and ethnic groups. The prevalence of myopia in black males decreased from 34,0% at the age 40 to 49 years to only 10,5% at the age of 80 years. For the similar age groups white females presented with a decline 42,1% to 12,9%. The Framingham Offspring Eye Study conducted from May 1989 through October 1991 found the exact same trend. The prevalence of myopia decreased from 52,0% in people between the age of 35 and 44 years to just 20% in those who were between 65 and 74 years old.

It is important to realise that these three studies were all done at approximately the same narrow span of time and during the time that numerous studies reported on the increase in myopia across the globe. Myopia was therefore seen as a function of age with the younger people being more myopic and more exposed to myopigenic factors such as increased near work demands. Therefore, not much attention was given to the possibility of a shift away from myopia in older adults. This probably also explains the contradictory results and lack of consensus since it depended on whether a cohort or date of birth approach was followed in explaining the results. These studies are therefore more cross sectional in nature rather than providing longitudinal data. Furthermore, during this era most studies received funding to assist governments to predict future health care needs and it is maybe understandable that researchers were more concerned regarding an increase in myopia in presbyopic people because this may indicate pathological changes such as nuclear cataracts and diabetes [2].

The hyperopic shift

It was only towards the end of the 20th century that researchers began to focus more on refractive changes, or more specifically a hyperopic shift in myopic eyes in the presbyopic population. This is somewhat surprising since Donders [6], in his epic work on accommodation published in 1864, already alluded to this hyperopic shift in presbyopia.

As mentioned before, I am personally experiencing this phenomenon and can therefore associate myself with the statements made by Morgan [7] in a paper entitled 'My aging eyes'. He made the point that one of the unfortunate consequences of aging, in his case, was the loss of his myopia. He reported that his refractive error (spherical equivalent, right and left eyes) at age 36 was -3.25 D and -2.12 D; whereas 37 years later it was -1.12 D and +0.25 D.

He commented that whereas he was formerly able to shave and read without his glasses, he was unhappy that he could no longer do so. He suggested that there were going to be a number of very unhappy senior citizens who had had successful refractive surgery when young adults. He suggested the term 'age-related hyperopia' to identify the hyperopic shift experienced by many myopes in their later years.

Grosvenor and Skeates (1999) [8] produced an excellent study in which they presented results from both a cross sectional study and a retrospective longitudinal study regarding these age-related refractive changes in presbyopia. In their literature review they also mentioned how difficult it is to compare the results from previously done cross sectional studies because the criteria for myopia differed greatly among the studies and the reports varied widely in regard to exclusion criteria (if exclusion criteria were mentioned at all). "However, most of the studies showing an increase in myopia during the later years of life were those that included eyes with age-related lens changes, whereas the studies showing a decrease in myopia were those in which eyes with lens changes were excluded.

More importantly, in no single study was the prevalence of myopia in the presbyopic years compared for populations of eyes having visual acuity of 6/6 or better and populations unselected on the basis of visual acuity". For longitudinal studies they found similar results to those presented earlier in this article. In studying patient records of vision care practitioners, they found overwhelming evidence of a hyperopic shift in emmetropic and hyperopic eyes, but less convincing evidence of a hyperopic shift in myopic eyes.

In the cross-sectional study, they compared age-related prevalence of myopia for patients having corrected visual acuity of 6/6 or better versus patients, who were unselected on the basis of visual acuity. The null hypothesis was that for each of the two groups of patients, the prevalence of myopia did not differ significantly for patients over 54 years compared to those of ages 45 to 54 years. In the retrospective longitudinal study, they reported refractive error data on patients who have been examined during periods varying from 10 to more than 20 years after age 40 years, with corrected visual acuity of 6/6 or better at all examinations. In this case they tested a null hypothesis that equal percentages of myopic, hyperopic and emmetropic eyes will show an age-related hyperopic shift during the presbyopic years.

Comparing results of the cross-sectional and longitudinal studies do provide challenges. Grosvenor and Skeates [8] stated that such a comparison is complicated by the fact that the results of cross-sectional studies are usually reported in terms of 'refractive error prevalence', whereas the results of longitudinal studies are usually reported in terms of 'changes in refractive error' during a stated period. However, in the longitudinal study, the concept of prevalence can be approached by determining the changes in the percentages of myopic, hyperopic and emmetropic eyes that occurred during the period of observation. Their results showed that only eight per cent of the initially myopic eyes 'lost' their myopia.

This again confirms that longitudinal studies should be done over much longer periods and they admit that the results were influenced by the limited period (mean, 13.8 years) of observation. Patients that presented with hyperopia at the onset of the study all remained hyperopic except for one person who became emmetropic. In the case of emmetropes 54% remained emmetropic, while 45% became hyperopic and one percent became myopic [8]. Again, these results may have been different if it was done over a longer time span. These results are in line with previous studies where an increase in the prevalence of myopia in the presbyopic years happens as a result of the development of cataracts [9]. The decline in the prevalence of myopia, on the other hand, is consistent with the studies previously mentioned [3,5].

What causes the hyperopic shift?

In an attempt to answer this question most studies focussed on changes in the structure of the crystalline lens in the eye. Donders [6] suggested that the growth of additional lens fibres during the adult years resulted in a flattening of the lens, which, if true, would account for the shift toward hyperopia. Far more recent studies using slitlamp photography, were able to show that the lens surfaces actually steepen with increasing age. This steepening will actually cause the eye to become more myopic and this phenomenon became known as the lens paradox (Ooi and Grosvenor [10]).

The fact that the index of refraction changes from the centre to the periphery of the lens has been known for a long time and researchers can now actually measure the index gradient of the lens confirming that the lens varies in the axial direction, with the index being

higher in the nucleus than in the cortex. The age-related change in the index gradient of the lens results in a decrease in its overall index of refraction (Hemenger et al, 1995) [11]. This decrease in the index from the centre to the periphery of the lens was more pronounced in older adults (49 to 61 years) than in young adults (19 to 35 years), indicating a decrease in the refracting power of the lens in the older adults (Garner et al,1999) [12].

According to Grosvenor and Keates [8] this decrease in the overall index of refraction (the gradient index) of the lens is more than sufficient to compensate for the steepening of the lens surfaces with the result that the image of a distant object focuses farther behind the retina, causing a change in the refractive state in the direction of increasing hyperopia or decreasing myopia.

Bomotti et al [2] state that it all comes down to one single factor and that is the severity of nuclear sclerosis. Nuclear sclerosis is an age-related change in the density of the crystalline lens nucleus that occurs in all older people and to them it explains the overall decrease in the refraction index caused by compression of older lens fibres in the nucleus by new fibre formation. Therefore, individuals with mild nuclear sclerosis will present with hyperopic changes in refraction with age.

At least researchers seem to agree that the hyperopic shift is all as a result of changes in the aging crystalline lens and that mild nuclear sclerosis is part of a normal aging process. Another alternative could be that there may be a decrease to the axial length in the eye [changes in axial length is still one of the main theories on the global increase in myopia over all populations and ages] but Mutti and Zadnik (2000) [13] claim that there is no evidence of any such changes to the axial length of the eye in presbyopic people.

What causes the myopic shift?

Although there is reasonable consensus on the etiology of the hyperopic shift, the same does not apply to what is causing the myopic shift. Grosvenor and Skeates [8] provided evidence of a continuous axial elongation that started in pre-presbyopic years, while for Bomotti et al [2] it again comes down to one factor and that is the severity of nuclear sclerosis. Grosvenor and Skeates [8] argued that the change in the gradient index of the lens that is responsible for acquired hyperopia is counteracted by continued axial elongation of the eye resulting in a considerable number of myopic eyes that remained stable or became more myopic during the presbyopic years.

Although it was formerly thought that axial elongation was responsible for the onset and progression of myopia only during childhood, they quote cross sectional studies that have shown that adult onset myopia is due primarily to axial elongation. They also quoted the results of longitudinal studies also showing that the progression of myopia in adults is due to continued axial elongation. At least they do mention the possibility that early, sub-clinical nuclear sclerosis could be responsible for a myopic shift, despite the presence of 6/6 corrected visual acuity. They do present a strong case by stating that such a mechanism would not be likely to account for situations in which an increase in myopia during the early presbyopic years is followed some years later by a decrease in myopia.

The study of Bomotti, et al [2] is probably the best longitudinal study to date. They did a follow up on the original Beaver Dam study and were able to include 83% of the original participants in their 2018 study. They were therefore able to produce results on etiological factors impacting on refractive changes in presbyopes over a 20-year period. This study confirms a hyperopic shift among individuals aged 40 to 70 (and corresponding decrease in myopia prevalence), followed by a clear myopic shift (and increase in myopia prevalence) after age 70.

This study also provided clarity on previous assumptions on birth date and cohort effects. They found that the refractive changes were independent of birth cohort and suggested that the changes in refraction over time in older individuals were primarily the development of age-related cataract. Birth year did not alter their trajectory of refraction in adulthood. However, baseline levels of refraction were affected by birth cohort; prior to the age of 70, individuals born more recently were more myopic. These cohort effects largely disappeared after age 70, and follow-up time was limited in the older cohorts. They were further able to show that after baseline refraction was accounted for, education did not influence longitudinal patterns in refraction, suggesting that the impact of education was on baseline levels of refraction but did not influence changes in refraction in later adulthood.

For some reason, Bomotti et al [2] regard all refractive changes during the presbyopic years as a function of nuclear sclerosis severity (that is if other pathologies are excluded). They do refer to other studies, also mentioned in this article to support their results and also include results from previous Beaver Dam Studies [14] and the Blue Mountains Eye Study [15] to confirm the strong relationship between nuclear sclerosis severity and myopic changes in refraction. Therefore, according to Bomotti et al [2], individuals with mild nuclear sclerosis will experience hyperopic changes, while those with moderate nuclear sclerosis will follow the same pattern but changes will level off after the age of 70 years. Individuals with nuclear cataract after adjustment for baseline age, baseline refraction, gender, education,

and diabetes status showed a 0.25D per year increase in myopia.

Conclusion

The results of the cross-sectional studies and retrospective longitudinal studies demonstrated a statistically significant age-related decrease in the prevalence of myopia during the presbyopic years. Of particular interest is the fact that refractive error changes were far more varied for myopic eyes than for hyperopic or emmetropic eyes. Whereas the majority of hyperopic and emmetropic eyes shifted toward hyperopia, myopic eyes changed by variable degrees, but the trend is now overwhelming to a reduced myopia in aging eyes.

How applicable are these results to the world of vision care? As we are finding a rapidly expanding body of literature reporting on the increase in the prevalence of myopia among all racial, ethnic and occupational groups it will become necessary to have a good understanding of what can be expected when this current population reaches presbyopia.

I am quite convinced that the decrease in myopia is associated with changes in the crystalline lens. The fact that patients who underwent cataract surgery show no changes in refractive status even years after the surgery [2] provides strong support to this statement.

Grosvenor and Skeates [8] raised a good point concerning refractive surgery. Because their longitudinal data showed that patients who are myopic at age 40 years have about a 20 per cent chance of becoming less myopic during the presbyopic years, we suggest that pre-presbyopic myopes who enquire about refractive surgery should be told of the possibility that they may become less myopic in future years, even without refractive surgery. McCarty et al [16] also warned about the possibility of a hyperopic shift in patients who are candidates for refractive surgery. As already mentioned, in discussing the loss of his own myopia during his presbyopic years, Morgan [7] suggested that there are going to be many unhappy senior citizens who had successful refractive surgery as young adults. I would support an under correction of -1.00. This may prevent the patient returning to total dependency on glasses or contact lenses.

Then lastly, I will not be surprised if future studies try to find a link between the accommodative lag theory for myopia progression in younger people and a reduced myopia in presbyopia due to accommodative function that is reduced in the aging lens.

Literature

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TEST 261 - What Happens to Myopia during Presbyopia? — Questions

1. Uncorrected refractive errors are considered to be:
   a. On the decline
   b. The same for last 50 years
   c. The main cause of visual im pairment across the globe
   d. Only b and c

2. The original data for the Beaver Dam study was collected during the late 1980s and the results show:
   a. A decline in the prevalence of myopia with age
   b. Myopia was found to be present in 42, 9% of presbyopes between the ages of 43 and 54 years
   c. This declined to only 14,0% in people 75 years and older.
   d. All of the above
   e. Only a and c

3. The Baltimore study:
   a. Focussed on an adult inner-city population
   b. Found a similar trend across gender and ethnic groups.
   c. The prevalence of myopia in black males decreased from 34,0% at the age 40 to 49 years to only 10,5% at the age of 80 years.
   d. Was done at almost the same time as the Beaver Dam study
   e. All of the above

4. It is understandable that researchers are more concerned regarding an increase in myopia in presbyopic people because this may indicate pathological changes such as nuclear cataracts and diabetes.
   a. True
   b. False

5. The contradictory results and lack of consensus on the decrease in the prevalence of myopia is the result of:
   a. Some researchers following a cohort approach
   b. Some researchers following a date of birth approach
   c. Longitudinal results were not considered
   d. All of the above.
   e. Only a and b

6. Donders [6] in his epic work on accommodation published in 1864 already alluded to this hyperopic shift in presbyopia.
   a. True
   b. False

7. Morgan in a paper entitled 'My aging eyes' made the following points:
   a. By aging he was losing his myopia.
   b. Reported to become more than 2.00 D less myopic over 37 years.
   c. He suggested the term 'age-related hyperopia'
   d. This will happen to everyone
   e. All of the above
   f. a, b and c only

8. Grosvenor and Skeates (1999) did:
   a. A cross sectional study
   b. A retrospective longitudinal study
   c. Investigate age related refractive changes in presbyopia.
   d. Find that 50% of the initially myopic eyes 'lost' their myopia
   e. All of the above
   f. a, b and c only

9. Cross-sectional studies are usually reported in terms of 'refractive error prevalence', whereas the results of longitudinal studies are usually reported in terms of 'changes in refractive error'.
   a. True
   b. False

10. Longitudinal studies on myopia change during presbyopia:
   a. Should be done over much longer periods than 15 years
   b. Results will not be influenced by limited period.
   c. Period only applicable on myopes not emmetropes
   d. None of the above

11. Researchers can now actually measure changes in the aging lens and found:
   a. That the index gradient of the lens varies
   b. The index being higher in the axial direction
   c. The index being very stable in the nucleus
   d. a and b

12. What causes the shift towards hyperopia?
   a. Diseases
   b. Cataracts
   c. Severe nuclear sclerosis.
   d. None of the above
   e. b and c

13. Nuclear sclerosis is:
   a. An age-related change in the density of the crystalline lens
   b. The main reason for cataracts
   c. In a mild form will cause increase in myopia
   d. All the above
   e. a and b only

14. The myopic shift is caused by:
   a. Continuous axial elongation that started in pre-presbyopic years
   b. Mild nuclear sclerosis
   c. Severe nuclear sclerosis
   d. a and c
   e. a and b

15. The 2018 Beaver Dam study confirmed:

a. A hyperopic shift among individuals aged 40 to 70
b. And corresponding decrease in myopia prevalence
c. Followed by a clear myopic shift
d. a and b only
e. all of the above

16. The Beaver Dam study produced the following results on refractive error change:

a. Far more varied for myopic eyes
b. Emmetropic eyes remained unchanged.
c. Majority of hyperopic eyes shifted toward more hyperopia
d. a and c
e. b and c

17. The increase in the prevalence of myopia will make it necessary to have a good understanding of what can be expected when this current population reaches presbyopia.

a. True
b. False

18. People who underwent cataract surgery:

a. Now show changes in refractive status
b. Increase in myopia
c. Increase in hyperopia

19. Pre-presbyopic myopes who had refractive surgery can expect:

a. No change during presbyopia
b. Increase in myopia
c. Increase in hyperopia

20. Decrease in the axial length in the eye, resulting in less myopia, is a possibility in presbyopic patients.

a. True
b. False