CAN CONTACT LENSES CONTROL THE PROGRESSION OF MYOPIA?

L S Heng, C Y Khoo

ABSTRACT

Myopia is a potentially blinding condition with serious socio-economic ramifications. Many causes have been alluded to and one of the strongest associations is that of formal education and nearwork. Studies done both locally and abroad illustrate this. In addition, Singaporeans were found to have one of the highest incidences of myopia in the world.

Many methods, including the use of contact lenses, have been advocated in the control of myopia. Hard contact lenses and more recently, rigid gas permeable lenses, have been studied both to arrest the progression of myopia in the young and reduce existing myopia (by orthokeratology) in the Caucasian population. However, the Asian eye differs from the Caucasian eye. This is evidenced by the increased frequency and severity of myopia, and the difference in the pattern of corneal diseases in our population. As such, there is a need for local studies to be conducted to assess the effectiveness of this method in our population.

Keywords: *myopia, myopia control, contact lenses, rigid gas permeable lenses, orthokeratology.*

SINGAPORE MED J 1994; Vol 35: 367-370

INTRODUCTION

Myopia is a condition in which parallel rays of light derived from an object at infinity is focused in front of the retina when the eye is at rest (Donders 1864)[1].

The refractive components of the eye would include its axial length, lens and corneal refractive power (curvature). Myopia results from a combination of these elements and their relationship to each other, ie the myopic eye is one in which the refractive system is too strong for its axial length.

Whilst the optical basis is easily understood, the problem remains complex as its cause, prognosis, natural history and treatment remain obscure. For example, a plethora of causes of myopia have been suggested. These include convergence, poor reading posture, dim illumination, elevated intraocular pressures, eye rubbing, congestion, uncorrected astigmatism or exophoria, dietary deficiencies, infectious diseases, scleral weakness and nearwork[2].

Although myopia may be congenital or develop in the pre-school child, it is most frequently observed in school children. This is a cause of concern because it is a cause of significant visual disability in young people who are at the peak of their creative ability. Apart from occupational restrictions, progressive myopia may also lead to irreversible changes in the eye associated with significant visual loss or blindness.

Visual Activity and Myopia

One of the strongest associations with myopia is that of visual activity. Refractive errors have been convincingly associated with the degree of formal education. Danish studies by Tscherning in 1882[3] and subsequently repeated by Goldschmidt in 1968[4] found that one-third of men admitted to university education had myopia of greater than 1.5 dioptre (D) compared with 2-3% for unskilled workers. A graded decrease in myopia was found for those with intermediate education. Similar findings were found in the United States by Sperduto et al (1983)[5].

In a local study done between April 1987 to January 1992, 110,236 Singaporean males between 15-25 years were assessed[6]. The study population was as follows: Chinese 88,315 (80.1%), Malay 12,854 (11.7%) and Indian 8138 (7.4%) and Others 929 (0.8%). The prevalence of myopia among this group by race is summarised in Table I and the prevalence of myopia by educational attainment is shown in Fig 1.

Table I – Prevalence of myopia among young Singaporean males (all educational groups) by race.

Race	Total No. of Males	Myopia	
		No. of Males	Prevalence
Chinese	88,315	42,804	48.5%
Malay	12,854	3,144	24.5%
Indian	8,138	2,474	30.4%
Others	929	322	34.7%
Total	110,236	48,744	44.2%

Source: Singapore Med J 1993; 34: 29-32.

An earlier similar study by Chew, Chia and Lee between 1974-84 surveyed a total of 320,409 men who had undergone full physical examinations[7]. Similar results were obtained. Of interest is the distribution of high myopes (> -7D) on the differing educational levels. It was also noted that whilst the proportion of very high myopia (> 10D) was almost unchanged amongst the various levels, those between 7-10D increased significantly with the level of education. The implication therefore is that school myopia in our population can reach a pathological degree of severity.

This data collected locally once again confirmed a significant association between educational attainment and the prevalence and severity of myopia. Thus, the association of refractive error with education is strong, consistent and dose dependent.

As formal education is a reflection of nearwork, more direct studies of visual activity or refractive errors were conducted. Results of studies by Ashton in 1985[8] were suggestive of an

Heng Eye Clinic & Surgery
3 Mount Elizabeth #14-09
Mount Elizabeth Medical Centre
Singapore 0922

L S Heng, FRCS, FC Ophth, M Med (Ophth)
Ophthalmologist

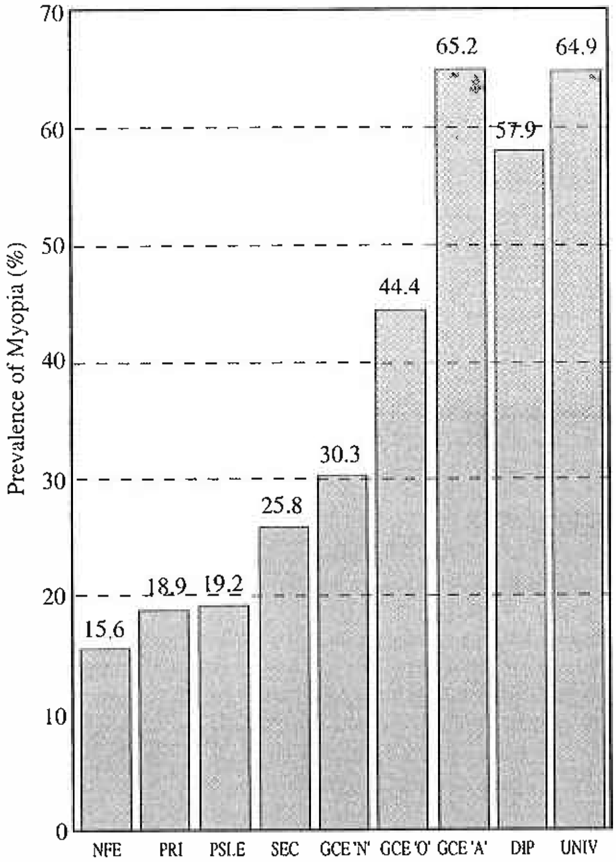
Drs Lim & Khoo
6A Napier Road #02-38
Annexe Blk, Gleneagles Hospital
Singapore 1025

C Y Khoo, FRCS, FRACS, FC Ophth
Consultant Ophthalmologist

Correspondence to: Dr L S Heng

association whilst studies by Angle and Wissman (1980)[9] and Richler and Bear (1980)[10] found statistically significant association.

Fig 1 – Prevalence of myopia (By educational attainment)



NFE : No formal education
PRI : Primary education (Less than 6-8 years of education)
PSLE : Successfully completed 6-8 years of education
SEC : Secondary (Less than 4 years of secondary education)
GCE 'N' : Passed the General Certificate of Education (Normal) Level
GCE 'O' : Passed the General Certificate of Education (Ordinary) Level
GCE 'A' : Passed the General Certificate of Education (Advanced) Level
DIP : Diploma (Successfully completed 3-year diploma course)
UNIV : University (Successfully completed 3-5 years of university education)

In our increasingly competitive society where paper qualification is thought to be the key to future success, great emphasis has been placed on obtaining a good formal education. We have also consequently observed a significant rise in the frequency of myopia.

The Local Scene

The increasing incidence of myopia in our school children has been a cause of concern in Singapore. Indeed, next to Japan, Taiwan and Hong Kong, we have one of the highest incidence of myopia in the world.

A study done on 128 third-year medical students (aged 20-22) confirmed this. The group which comprised predominantly Chinese students, 44% females and 56% males, had an 82% incidence of myopia. The mean refractive error for the females was -4.76D and that for males was -3.75D[11].

In another study on myopia in school children between April 1984 - July 1985, the Ministry of Health surveyed 8,082 10-year-old children in Primary 4. There were 4,189 boys and 3,893 girls. 69.1% were Chinese, 16.3% Malays and 4.1% Indians. 64.8% of the children had myopia of at least 0.5 dioptre, making the prevalence 24.9%. The prevalence rate of myopia amongst Chinese was significantly higher (28.9%) than Malays and Indians (15.1% each). There was no significant difference found between the sexes[12].

Also highlighting this problem in Table II is the result of a survey done on school children done between 1985 and 1989 on defective vision by educational level[13]. In 1987, 14.34% of Primary 1 students had vision of 6/18 or worse, rising to 55.56% in the Secondary 4 students. In 1989, 19.01% of Primary 1 students had the same vision, rising to 57.75% in the Secondary 4 students. In terms of total percentages, there has been a steady rise of those with defective vision (6/12 or worse) by about 2-3% per year! It is therefore of great interest whether myopia can be controlled or its progression halted.

Use of Hard Contact Lenses in Myopia Control

Many methods have been advocated in the control of myopia. These include under-or-over correcting the myopia, use of bifocal lenses, use of minus lenses for distance only, use of eye exercises or visual training, daily instillation of pharmaceutical agents and surgery (including laser). Contact lens use has also been advocated in the control of myopia. Two techniques have been used. Conventional fitting of lenses has been used in an attempt to arrest or reduce progression of myopia in the young. Alternatively, orthokeratology or intentional flattening of the cornea, with

Table II – Defective vision by educational level (1985 – 1989).

	Visual Acuity > 6/18				Visual Acuity > 6/12					
	1985		1986		1987		1988		1989	
	No.	%	No.	%	No.	%	No	%	No.	%
Pri 1	3,473	8.89	3,731	9.36	5,726	14.34	6,548	16.28	7,801	19.01
Pri 6	15,546	32.96	15,770	36.78	18,289	46.03	21,579	50.51	19,959	52.07
Sec 4	16,907	45.21	17,521	49.08	19,567	55.56	20,435	52.85	21,854	57.75
Total	35,926	29.06	37,022	31.26	43,582	37.94	48,562	39.84	49,614	42.04

Source: Personal communication with Dr. Uma Rajan, School Health, Ministry of Health Singapore.

fitting of flat lenses, has been used to try to reduce the amount of existing myopia in adults.

The effectiveness of contact lenses in the control of myopia has been a matter of controversy since 1956. Morrison reported that over a two-year period, a large number of young myopes (1,021), aged between 7-19 years, fitted with polymethyl methacrylate (PMMA) lenses showed no progression of myopia[14]. His patients had been fitted from 1.62 to 2.50D flatter than the flattest corneal meridian. In a subsequent report in 1960, it was found that progression of myopia was also halted when he used the conventional alignment method of fitting[15].

The possible factors involved in the control of myopia with contact lenses were discussed by Bailey in 1958[16]. The apparent stabilisation was thought to be due to the following factors:

i) The flattening of the cornea.
ii) Decrease of axial length as a result of reduced anterior chamber depth secondary to the flattening.
iii) Overcorrection of the myopia due to presence of photophobia during the initial and subsequent refraction while wearing the lenses.
iv) Reduced tear film thickness due to settling of the lenses on the cornea.
v) Failure to take effective power into consideration when ordering the contact lenses.
vi) Ophthalmometer error in the verification of finished lenses.
vii) Tendency for a practitioner to overlook myopic overcorrections during subsequent follow ups.

Many studies are carried out using PMMA lenses for myopia control. Of interest are the studies by T. Stuart-Black Kelly and colleagues from Bath[17] and Stone and her colleagues[18].

In the 1975 study from Bath, a large study comprising children first noted to have myopia between ages of 10 and 15 years was conducted. Five groups were formed. Group 1 was the control group which was treated with conventional lens refraction and spectacles. Group 2 was given bifocals at atropine correction and treated with phenylephrine 5% drops at night. Group 3 was treated with contact lenses only. Group 4 comprised failures who were treated with contact lens subsequently and Group 5 comprised children who were treated with atropine daily either as an initial treatment or as failures of Group 4.

In the control group, myopia increased steadily by half a dioptre per year until 18-23 years of age. All controls showed increased myopic changes after 4 years of follow-up.

In Group 2, refractions were less myopic by an average of 1/2 dioptre by 3 months and these arrests lasted a considerable period.

In Group 3, the arrest rate over 4 years was 38%. The arrest rate stayed between 20 to 30% for as long as 13 years. However, 1 to 2 eyes in this group, as in the control group, showed significant worsening of the myopia.

Of interest is that Group 4 showed that two-thirds had arrested myopia after 6-9 months of contact lens use despite having failed treatment previously. Group 5 children on daily atropine drops also showed arrest of myopia.

Although it was neither a randomised or matched study, the results obtained were suggestive that treatment using contact lenses with or without pharmaceutical agents was able to arrest or reduce the amount of myopia.

One of the most definitive studies on the use of PMMA lenses for myopic control was carried out by Stone and colleagues[19]. In a 5-year study comprising 84 subjects and 40 matched controls, the mean increase in myopia for contact lens wearers was found to be 0.10D per year compared with spectacle wearers of 0.35D per year (controls). Children in the experimental group were fitted with lenses of diameter 9.2mm or smaller, and an optic zone width of 7mm or smaller, fitted just steeper than the flattest keratometer readings. It was found that the corneal changes were much less than the change in refraction and hence myopia correction could not be solely due to corneal flattening. However, axial length was not measured and the effect of contact lens use on this factor was not known.

Orthokeratology or the practice of fitting contact lens to reduce myopia by flattening the cornea is well known. The flattening, however, is not permanent. In most cases, "retainer" lenses have to be worn at least on a reduced basis to maintain this effect.

In a large clinical study, Kerns (1976, 1977, 1978) compared 26 controls (conventional contact lens wearers) with 36 eyes (subjects)[20-22]. These subjects were fitted with thicker, flatter and larger lenses so as to induce flattening. Kerns found that with any given patient the results were not predictable. On the average, at the end of the study, subjects had about 1 dioptre less myopia than controls, but had 0.5D more astigmatism.

In another large scale randomised clinical trial, Polse et al (1983) studied about 40 controls and 40 subjects[23]. Once again, larger and thicker lenses were fitted flatter than the controls. Similar findings of a reduction of 1D of myopia compared with 0.5D for controls were found. Astigmatism was however not found in this trial and was attributed to the centration of the fit of the lenses in these subjects.

The "2:1" ratio in orthokeratology is a concept in which the reduction in myopia is approximately twice the dioptric amount of corneal flattening. This ratio was investigated by Erickson and Thorn using data from 4 orthokeratology studies[24]. On the average there was a reduction of 0.72 dioptre when there was no change in the keratometric readings. When there was a change, the reduction in myopia failed to keep up with the keratometric changes in this ratio.

The suggested reason was that in the treatment, corneal flattening occurred primarily at the apex and then secondarily at the surrounding annulus. As it was only the latter that was measured, these keratometric readings may not be a valid method of assessing the effect of lenses on corneal curvature and its relationship in myopia control.

Of note is that orthokeratology is only able to minimally reduce myopia and hence is suitable only in low myopes. In addition, one can conclude that corneal flattening is not the only factor in the reduction of myopia by contact lenses.

Rigid Gas Permeable (RGP) Lenses in Myopia Control

Interest in myopia control with contact lenses abated with popularity of soft hydrogel lenses. However, with the introduction of hard gas permeable lenses, this interest was rekindled.

A 3-year study at the University of Houston in 1985 attempted to answer the following questions[25-27]:

i) Are RGP lenses effective in controlling the progression of myopia?
ii) To what extent is it due to corneal flattening?
iii) Does RGP lenses control the axial elongation of the eye?
iv) Is the stabilisation effect permanent?

Grosvenor and his colleagues fitted 100 myopic children (aged 8 to 13 years) with Paraperm O_2 and silicone-acrylate gas permeable contact lenses. These children had normal eyes, apart from myopia and no more than 2D of astigmatism. They were matched with a control group of twenty single-vision spectacle wearers by initial age and initial amount of myopia.

Most subjects were fitted with lens diameters of 9mm and optic zone width of 7mm by the alignment method. The blind study was conducted by 2 teams – an evaluation team and a patient care team. The evaluation team made baseline measurements of refraction, keratometry and axial length. Subsequent yearly measurements were made on subjects on a Saturday morning before they put their lenses on, after having worn their lenses on a full time basis up to and including the day before the testing. The patient care team supervised the contact lens fitting and follow up care. Changes in the lenses were made as needed during the study.

Fifty-six of the 100 subjects remained in the study. The mean increase in myopia in the subjects was 0.16D per year (or 0.48 ± 0.70D over 3 years) compared with 0.51D per year (or 1.53 ± 0.81D over 3 years) in the controls. Hence, over the 3-year period, the mean increase in myopia was 1D greater in the spectacle wearing (control) group than in the contact lens wearers.

In the contact lens wearers, there was a mean corneal flattening of 0.37D and a mean axial length increase of 0.48mm. Incomplete data was obtained on the controls. However in the data published by Fledelius (1982), little change in corneal refracting powers would be expected in this age range and similar myopes had a mean increase in axial length of 0.49mm[28,29]. Although statistically not significant, results of this Houston study pointed to a trend of reciprocal relationship between corneal flattening and axial elongation. The likely cause is due to the slight decrease of anterior chamber depth secondary to corneal pressure by the contact lens. This effect would also be manifested as a decrease in progression of myopia.

The effect of discontinuation of contact lens wear on myopia has previously been studied by Rengstorff[30,31]. He found a gradual increase in myopia back to initial values over a period of 21-48 days. To study the permanency of RPG lenses in controlling myopia, the Houston group at the end of the 3-year study asked subjects to give up contact lens wear over a period of time. Twenty-three subjects discontinued lens wear for an average of 2-5 months. During this period, there was a mean increase on myopia of 0.27D and a mean corneal steepening of 0.25D. In totality, comparing the mean values of the contact lens wearers and the spectacle wearers over the entire study period, the amount of progression is still smaller [(0.48 + 0.27 = 0.75) D vs 1.53D] in the former group.

The conclusions of the Houston study are as follows:

i) RGP lenses are able to control myopia to a significant degree. However, due to a large standard deviation in both control and subject groups, it would not be possible to predict the effect of contact lenses in controlling myopia for a given patient.
ii) About half of the effect of contact lenses in controlling myopic progression is due to corneal flattening as measured by the keratometer. However, the keratometer may not be a valid method of measurement in these circumstances.
iii) The results did not confirm that RPG lenses could control axial elongation of the eye.
iv) The effect of lenses in controlling myopic progression required continued lens wear. This effect was also found to persist when lens wear was resumed following a period of discontinuation over a few months.

CONCLUSION

What are some of conclusions that can be drawn and what are its implication for us locally?

Basically, myopia is a very complex subject. Its aetiology is multifactorial with contributions from genetics, environment, associated systemic conditions and visual activity. Locally, myopia is reaching pandemic proportions; yet there is a paucity of studies done in our population. Due to differences in genetic and structure of the Asian eyes, the nature of myopia and its response to the various modalities of treatment described previously may differ from Caucasian eyes.

One obvious difference is the greater incidence of higher degrees of myopia in our young children. Other differences include the pattern of corneal diseases – there is a lower incidence of keratoconus (warpage of the cornea) and corneal dystrophies in our population. All these point to the likelihood that there are significant differences between the Caucasian and Asian eyes. As such, there is a need to conduct comparable well designed studies to determine if RPG lenses are able to control myopia in our local population.

REFERENCES

1. Donders FC. On the anomalies of accommodation and refraction of the eye. London. The New Sydenham Society 1864
2. Curtin BJ. The myopias: basic science and clinical management. Philadephia: Harper and Row, 1985.
3. Tscherning M. Studies over myopiens aetiologi. Copenhagen: Kobenhaun 1882.
4. Goldschmidt E On the etiology of myopia: an epidemiological study. Acta Ophthalmol 1968 (suppl); 98:1 +.
5. Sperduto RD, Siegel D, Roberts J, Rowland M. Prevalence of myopia in the United States. Arch Ophthalmol 1983; 101:405-7.
6. Au Eong KG, Tay TH, Lim MK. Race, culture and myopia in 110,236 young Singaporean males. Singapore Med J 1993; 34:29-32.
7. Chew SJ, Chia SC, Lee KH. The pattern of myopia in young Singaporeans. Singapore Med J 1988; 29:201-11.
8. Ashton GC. Nearwork, school achievement and myopia. J Biosoc Sci 1985; 17:223-33.
9. Angle J, Wissman DA. Age, reading and myopia. Am J Optom Physiol Optics 1978; 55:302-8.
10. Richler A, Bear JC. Refraction, nearwork and education: a population study in Newfoundland. Acta Ophthalmol 1980a; 58:468-78.
11. Chow YC, Dhillon B, Chew PT, Chew SJ. Refractive errors in Singapore medical students. Singapore Med J 1990; 30:472-3.
12. Ling SC, Chan AJ, Rajan U, Cheah WM. Myopia in ten-year-old children – a case control study. Singapore Med J 1987; 28:288-92.
13. Personal communication with Dr. Uma Rajan, School Health, Ministry of Health Singapore.
14. Morrison RJ. Contact lenses and the progression of myopia. Optom Weekly 1956; 47:1487-8.
15. Morrison RJ. The use of contact lenses in the adolescent myopia patients. Am J Optom Arch Am Acad Optom 1960; 37:165-8.
16. Bailey MJ. Possible factors in the control of myopia with contact lenses. Contacto 1958; 2:114-7.
17. Kelly TS, Chatfield C, Tustin G. Clinical assessment of the arrest of myopia. Br J Ophthal 1975; 59:529-38.
18. Stone J. Contact lens uses in the young myopes. Br J Physiol Opt 1973; 28:90-134.
19. Stone J. The possible influence of contact lenses on myopia. Br J Physiol Opt 1976; 31:89-114.
20. Kerns RL. Research in orthokeratology. J Am Optom Assoc 1976; 47:1047-51, 1275-85, 1505-15.
21. Kerns RL Research in orthokeratology. J Am Optom Assoc 1977; 48:227-38, 345-59, 1134-47, 1541-3.
22. Kerns RL Research in orthokeratology. J Am Optom Assoc 1978; 49:308-14.
23. Polse KA, Brand RJ, Schwalbe JS, Vastine DW, Keener R. The Berkeley orthokeratology study. Part II: Efficacy and duration. Am J Optom Physiol Opt 1983; 60:187-98.
24. Erickson P, Thorn F. Does refractive error change twice as fast as corneal power in orthokeratology? Am J Optom Physiol Opt 1977; 54:581-97.
25. Perrigin J, Perrigin D, Quintero S, Grosvenor T. Silicone acrylate contact lenses for myopia control: three year results. Optom Vis Sci 1990; 67:764-9.
26. Grosvenor T, Perrigin D, Perrigin J, Quintero S. Rigid gas permeable lenses for myopia control: effects of discontinuation of lenses. Optom Vis Sci 1991; 68(5):385-9.
27. Grosvenor T, Perrigin D, Perrigin J, Quintero S. Do rigid gas permeable contact lenses control the progress of myopia? Contact Lens Spectrum 1991; 6:7.
28. Fledelius HC. Ophthalmic changes from ages of 10 to 18 years III. Acta Ophthalmol 1982a; 60:393-402.
29. Fledelius HC. Ophthalmic changes from ages of 10 to 18 years IV. Acta Ophthalmol 1982b; 60:403-11.
30. Rengstorff RH. Studies of corneal curvature change after wearing contact lenses. J Am Optom Assoc 1969; 40:298-9.
31. Rengstorff RH. Relationship between refraction and corneal curvature change after wearing contact lenses. Am J Optom Arch Am Acad Optom 1969; 46:357-62.