International survey of contact lens fitting for myopia control in children

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Abstract

Purpose. To determine the extent of contact lens fitting for myopia control (MC) in children (defined as ≤ 17 years of age) worldwide and to characterize the associated demographics and fitting patterns. **Methods.** Survey forms were sent to contact lens fitters in 66 countries between January and March every year for eight consecutive years (2011 to 2018, inclusive). Practitioners were asked to record data relating to the first 10 contact lens fits performed after receiving the survey form. Data were analysed for those countries reporting ≥ 100 contact lens fits to children. **Results.** Data were analysed for 535 MC fits and 23,830 other (non-MC) lens fits undertaken in 31 countries reporting ≥ 100 contact lens fits to children, with 52.1% of MC fits and 12.0% of non-MC fits being with rigid lenses ($p < 0.0001$). Overall, MC lenses represented 2.3% of all contact lens fits to children, with significant differences between nations ($p < 0.0001$), ranging from no MC fits recorded in the Czech Republic, Greece, Japan, South Korea and Puerto Rico, to 24.9% in Austria. There has been an increase in contact lens fitting for MC over the survey period ($p < 0.0001$). MC contact lenses were fitted to younger children compared to non-MC lenses (MC, median 13 years vs. non-MC, median 15 years) ($p < 0.0001$). There was no sex bias in the fitting of MC lenses ($p = 0.89$). **Conclusions.** MC lenses are currently being prescribed for younger children in equal measure in terms of soft vs. rigid lenses and males vs. females. The extent of MC fitting is low and varies between nations. The gradual increase in MC fitting throughout the survey period perhaps reflects growing concerns among practitioners over the myopia epidemic.

Keywords	contact lenses; fitting; myopia control; survey
Taxonomy	Contact Lens Prescribing, Soft Contact Lens, Rigid Gas Permeable Lens
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Submission Files Included in this PDF

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Response to Reviewers.docx [Response to Reviewers (without Author Details)]

Highlights.doc [Highlights]

Title Page.docx [Title Page (with Author Details)]

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Figure 1.pdf [Figure]

Figure 2.pdf [Figure]

Figure 3.pdf [Figure]

Figure 4.pdf [Figure]

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Research Data Related to this Submission

There are no linked research data sets for this submission. The following reason is given:
Data will be made available on request

Response to Reviewers of the Paper
International survey of contact lens fitting for myopia control in children

Reviewers comments in bold font.

Our response in plain (non-bold) font

Changes in the manuscript highlighted in yellow.

Comments from the editors and reviewers:

Guest Editor

This is an interesting survey to evaluate the extent of prescribing myopia control contact lenses over a 8 year period throughout the world.

Agreed!

Given the current interest in MC by ECPs it is surprising to see the low number of fits for MC in children.

Although the numbers are low, we point out that the rate of MC prescribing is increasing over time.

Some minor comments from the reviewers need to be considered.

We have considered all comments and responded as indicated below.

In addition how did you determine that practitioners were randomly selected to take part in the survey? - I see details for this for the UK but not for other countries.

This information has been presented in considerable detail in the second and third paragraphs of section 2.1, with various examples of the approach adopted in different countries, aside from the UK

What would be the normal variation in response if the survey was repeated in one year with a different cohort of practitioners? i.e. how does practitioner selection potentially alter the results?

It appears from our experience over 25 years, in conducting this survey in over 60 countries, that year-on-year variances have little impact on the results. Clear, consistent and intuitively plausible trends are observed in respect of numerous parameters assessed, even though, as the Guest Editor correctly surmises, different sets of practitioners are completing the survey each year. Thus, we believe ‘practitioner selection’ introduces only minimal noise to the overall strong signals observed.

In the introduction you state the use of surgery, optical or pharmacological interventions for myopia control. Some researchers advocate change in behaviour and that could also be mentioned.

Yes, good point. We have now mentioned this (outdoor light exposure) and introduced a new reference (reference 6) in support.

The timeline for introduction of MiSight CLs to the market was much earlier in Spain and Australia compared to the UK for example and this may reflect some of your findings.

Another good point, although it is even more complicated than this. MiSight was not available in all countries surveyed, and was introduced into some countries at different stages throughout the 8-year course of the work. At the time of writing this paper, the MiSight lens was available in only 14 of the 31 countries surveyed. We have now mentioned this in the paper (first paragraph of Discussion), and have highlighted in the caption to Figure 1 those countries where MiSight was available at the time of writing. This information will assist readers in relating our data to the availability of MiSight.

Some countries have no access to atropine for MC even if it is off-label i.e. UK.

This is true; however, we have deliberately avoided detailed discussion of surgical, pharmaceutical and behavioural approaches to myopia control in this paper, which is of course about contact lens prescribing for myopia control. Detailed discussions of these other approaches are beyond the scope of this paper, apart from the very brief mention in the Introduction to provide broad context.

Reviewer 1

This manuscript describes a survey that was administered over an 8-year period to determine the extent of contact lenses fitted for myopia control around the world. I have some reservations about the methodology – there is little justification for the techniques used to analyse the data. I have some other comments below:

We have responded below to the details raised.

Line 44: using atropine and pirenzepine is also considered off-label use for myopia control

This is true, and we have added this point to the sentence in question.

Line 45: remove peripheral. This is one of the mechanisms by which optical strategies is believed to induce myopia control effects

We have now qualified this statement by noting that this is one possible mechanism of myopia control. We have also replaced the reference of Charman and Radhakrishnan with a more appropriate reference that highlights this debate (the details of which are beyond the scope of this paper).

Line 96: how did authors determine the threshold value of 100 fits?

There is no 'hard and fast' rule to determine this threshold but this was an attempt to rule out markets with small responses to eliminate spurious inter-country comparisons. Our data allows for the estimate of myopia control lens fitting to have 95% confidence limits of +/- 10% of fits or better (lower) which, in our judgement, allows for meaningful comparisons between markets.

Line 100: is calculation of this weighting factor a verified technique?

The weighting of lens fits is an effort to provide better estimates of prescribing trends. Clearly, a practitioner who completes 10 lens fits in one day is very likely to be prescribing more contact lenses in a year than someone who takes one month to reach the same number of fits. We believe that our approach appropriately caters for this situation. It is not clear how this might be formally 'validated' so instead, we clearly report our method for readers to take into account when they consider the paper. We are also reassured by the observation that this same approach – carefully outlined each time – has featured in approximately 50 refereed scientific papers and 70 clinical articles which we have written in this area over the past 25 years.

Line 123: I find it unusual that places such as Japan and South Korea, which have significantly high myopia prevalence rates, recorded no contact lens fits for myopia control?

We speculate this could be due to the fact that myopia control on the whole at the moment requires off label prescribing and these two countries are not known for their poor compliance to regulatory control.

Discussion: there should be some discussion about the limitations/assumptions made in methodology.

We have introduced a discussion of the limitations of this work in the last paragraph of the Discussion section of the paper.

Reviewer 2

This is a relatively straightforward article that uses a subset of data, collected as part of a large international survey, to examine the extent of myopia control management that occurs with contact lenses in different countries. The results are to some extent interesting and highlight the different approaches of countries to myopia control. In addition the results may reflect the extent to which contact lens companies such as Coopervision have gained access to specific countries. I have a few comments that the authors should consider prior to publication.

We have addressed these comments, as indicated below.

Introduction

Line 44: use MC instead of myopia control

We have replaced ‘myopia control’ with MC.

Line 45: The sentence relating to peripheral positive spherical aberration is too simplistic and is not a true representation of reference 9.

Fair comment. We have re-edited this sentence and introduced a new reference to reflect the ongoing discussion about the aetiology of myopia control. See our response to the Guest Editor who raises a similar point.

Methods

Line 78: I think the authors should just say that the survey was conducted in the first few months of each year. The text relating to seasonal influences etc implies a degree of control which is not apparent when you consider the differences in climates, seasons etc in the countries surveyed.

We have made this change.

Results

Line 129: The “overall extent” is confusing – the proportion that MC fits has increased would be more informative.

We have made this change.

Discussion

Line 192 and 202: the term “myopia epidemic” is mentioned initially in relation to East and South East Asia (ref 10) and then less specifically (ref 16). I think the authors should be careful when discussing this as line 202 gives the impression that the epidemic is global.

Yes, we have re-worded the text and referred to the “growing awareness among eye care practitioners of the importance of arresting myopia progression where possible”.

Line 176 – this statement needs to be discussed. Were the soft lens MC values higher in countries where MiSight was introduced earlier? Relate this to examples from figure 1 to provide more evidence.

This is a good point. Please see our response to the Guest Editor, who essentially raised the same issue.

Figure 1 The large error bars in figure 1 for AT, DE and HK suggest that there has been a large change in MC prescribing over the survey period

These large error bars reflect great year-to year variance in MC prescribing in these countries. However, this variance has not precluded the demonstration of highly significant differences between countries, and we have presented the statistical evidence for this.

Figure 3 legend: “as a proportion of all soft and rigid lens fits in children”. It would also be useful to have an idea of the n number here as percentages can be confusing.

We feel that this graph is abundantly clear. ‘Percentages’ are a well-understood statistical descriptor. To include the 16 ‘n’ data values in the graph and/or caption would be cumbersome, would make this figure unwieldy, and would seriously detract from the message we are trying to deliver. The total ‘n’ for this work is given in the Results section.

The data for 2013 is also worthy of mention.

Data for 2013 is the same as data for 2011. By the same token, data for 2012 is the same as that for 2014 and 2015. The reviewer seems to be suggesting the 2012 data is spurious. But the same could have been said about the 2013 data. The point here is that there will always be variances in data, that cannot always be easily explained; it is important to focus on *overall* trends, which we have done.

Figure 4 legend: this legend requires more detail. Again, an n number would be useful for the two groups when dealing with proportions.

It is the proportion of wearers that is important here, which serves as a valuable tool for normalising the graph for ready comparison of MC and non-MC age data. To include the 34 ‘n’ data values in the graph and/or caption would be cumbersome, would make the graph unwieldy, and would seriously detract from the message we are trying to deliver. The total ‘n’ for this work is given in the Results section.

Highlights

- A survey of contact lens prescribing for myopia control in children was conducted annually in 31 countries between 2011 and 2018, inclusive.
- Myopia control fits represented 2.3% of all contact lens fits to children, although the extent of myopia control fitting has slowly increased over time.
- A similar proportion of females (58.1%) was fitted with myopia control lenses versus non-myopia control lenses (62.3%).
- The median age of myopia control and non-myopia control fits is 13 and 15 years, respectively, with most myopia control fitting activity taking place among children aged 8 to 15 years.
- Of all contact lenses fitted for the purpose of myopia control to children, 52.1% were undertaken using rigid lenses; this compares with 12.0% for non-myopia control fits with rigid lenses.

International survey of contact lens fitting for myopia control in children

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4 Figures, 1 Table

Running header: Contact lens myopia control survey

1

2 International survey of contact lens fitting for myopia control in children

3

ABSTRACT

Purpose. To determine the extent of contact lens fitting for myopia control (MC) in children (defined as ≤ 17 years of age) worldwide and to characterize the associated demographics and fitting patterns.

Methods. Survey forms were sent to contact lens fitters in 66 countries between January and March every year for eight consecutive years (2011 to 2018, inclusive). Practitioners were asked to record data relating to the first 10 contact lens fits performed after receiving the survey form. Data were analysed for those countries reporting ≥ 100 contact lens fits to children.

Results. Data were analysed for 535 MC fits and 23,830 other (non-MC) lens fits undertaken in 31 countries reporting ≥ 100 contact lens fits to children, with 52.1% of MC fits and 12.0% of non-MC fits being with rigid lenses ($p < 0.0001$). Overall, MC lenses represented 2.3% of all contact lens fits to children, with significant differences between nations ($p < 0.0001$), ranging from no MC fits recorded in the Czech Republic, Greece, Japan, South Korea and Puerto Rico, to 24.9% in Austria. There has been an increase in contact lens fitting for MC over the survey period ($p < 0.0001$). MC contact lenses were fitted to younger children compared to non-MC lenses (MC, median 13 years vs. non-MC, median 15 years) ($p < 0.0001$). There was no sex bias in the fitting of MC lenses ($p = 0.89$).

Conclusions. MC lenses are currently being prescribed for younger children in equal measure in terms of soft vs. rigid lenses and males vs. females. The extent of MC fitting is low and varies between nations. The gradual increase in MC fitting throughout the survey period perhaps reflects growing concerns among practitioners over the myopia epidemic.

Key words: contact lenses, fitting, myopia control, survey.

1.Introduction

The term ‘myopia control’ (MC) has been coined to describe the practice of introducing an intervention to arrest the progression of myopia. There are four fundamental approaches to MC – surgical, pharmacological, behavioural, and optical. Surgical approaches have focused on posterior scleral cross-linking and appear to be applied to high levels of myopia [1-3]. Pharmacological approaches have centered around the use of the anti-muscarinic agents atropine [4] and pirenzepine [5]; these drugs have been demonstrated to partially arrest the progression of myopia in children, although the precise mechanism by which this occurs is unclear. Behavioural change relates to the notion that spending more time outdoors in sunlight can arrest the rate of progression of myopia [6].

Optical approaches include the use of bifocal or multifocal spectacles [7], and concentric ring bifocal or peripheral-add multifocal soft contact lenses that incorporate additional plus power in the lens periphery [8]. Orthokeratology contact lenses have also been reported as being able to arrest myopia progression, in addition to the classical myopia correction effect of this modality [9]. It should be noted that in most parts of the world, MC using spectacles, contact lenses and pharmaceutical agents (atropine and pirenzepine) is considered an ‘off-label’ (unregulated) use of a medical device or drug. Positive spherical aberration induced by these optical configurations is one possible mechanism that is thought to create a reduction in the stimulus for eye growth [10].

The increasing prevalence of myopia around the world – especially in Asian regions [11] – and the awareness of ocular pathology associated with high myopia [12], have heightened interest in clinical management strategies to arrest myopia progression. This paper examines trends in, and factors associated with, contact lens fitting for MC in children (≤ 17 years of age [13]) in 31 countries over an eight year period (2011 to 2018, inclusive). Such information can provide (a) a valuable yardstick for contact lens clinicians, against which they can assess their own prescribing approaches to MC, and (b) useful guidance to the contact lens industry on the clinical utilization of this relatively new product category.

2.Materials and methods

2.1 Conduct of the annual survey

Between January and March each year from 2011 to 2018, a contact lens fitting survey was undertaken in 66 countries. This was achieved through the offices of members of the International Contact Lens Prescribing Survey Consortium, which is a network of academics, industry representatives, and clinical colleagues who have agreed to manage the survey in their country or geographic region, as outlined below.

66

67 Each Consortium member was requested to send a paper or electronic (e-mail) survey form to as
68 many contact lens practitioners (opticians, optometrists and/or ophthalmologists, depending on the
69 market) in their country as possible, with a notional target of 1,000 surveys sent. Some smaller
70 countries were unable to reach this target due to the limited number of practitioners in that region.

71

72 In some countries, such as Australia, survey forms were sent by e-mail to virtually every
73 practitioner in the country (about 5,000). In other countries, survey forms were sent to a selection of
74 practitioners throughout the country; this process varied among countries, ranging for example from
75 a computer-generated random list of 1,000 recipients from the national practitioner register in the
76 UK, to a list of practitioner-subscribers to contact lens trade publications in the USA and Russia. In
77 larger countries with dispersed populations, such as China and Russia, survey forms were sent to
78 practitioners in a select number of major urban cities. The survey forms were sent together with a
79 request that they be completed and returned within three months of receipt. The survey was
80 conducted in the first few months of each year in all countries.

81

82 A standardized, one-sided, locally-translated survey form was used each year. Practitioners were
83 requested to enter a number of background details and to supply generic information about the first
84 ten contact lens fits performed after receipt of the survey form (Table 1). Practitioners were asked to
85 return the form irrespective of the number of patients seen (if fewer than 10). The returned forms
86 were logged and data from each form were manually entered into an Excel spreadsheet (Microsoft
87 Corporation, Redmond WA) to facilitate data analysis.

88

89 The Office of Research Ethics at the University of Waterloo, Canada, granted approval for this
90 work, and noted that, as the data being collected were (1) part of normal practice care provision, (2)
91 transcribed from the practice patient records, and (3) de-identified in respect of the patients and
92 source practice, then the requirement for patient informed consent was waived

93

94 *2.2 Statistical analysis*

95 Data were analysed for all contact lens fits to children, defined as those ≤ 17 years of age [13], in
96 countries where ≥ 100 fits were reported. Differences among practitioners in relation to the amount
97 of contact lens fitting performed were accounted for by assigning an appropriate weighting to each
98 recorded contact lens fit. This was achieved by estimating the number of contact lens fits performed
99 each year by each respondent (based on the date information provided on the survey form) and
100 using this as a weighting factor. For example, the data generated by a practitioner completing all 10

fits in one week were given twice the weighting of a practitioner who fitted 10 patients in two weeks. Data were mined with the aid of the Excel® Pivot Table function.

Analysis of the main differences in the dataset were conducted using logistic regression models (JMP, SAS Institute Inc., Cary NC, USA) to compare differences between children fitted with MC lenses versus those fitted with non-MC lenses. Further to this, a sub-analysis was conducted within the MC group only to compare differences in age and sex for those prescribed rigid lenses compared with those prescribed soft lenses. These differences were assessed statistically using a Mann Whitney U test and a chi-square test, respectively.

3. Results

3.1 Data collection

Over the 8 year survey period (2011 to 2018, inclusive), 31 eligible countries provided data for at least 100 contact lens fits to children, resulting in a total of 23,830 fits. In this sample, there were 535 contact lens fits designated as being for the purpose of MC and 22,295 standard lens fits (i.e. ‘non-MC’; these data were used in this study for comparison purposes). The median country response rate was 769 fits, ranging from 115 fits in Puerto Rico to 6,994 fits in Japan.

3.2 Participating countries

Averaged over the eight year survey period, contact lens fits for MC represented 2.3% of all contact lens fits to children; however, there was considerable variance in MC lens fitting among the 31 eligible countries surveyed ($\chi^2 = 539$, $p < 0.0001$), ranging from no fits recorded in the Czech Republic, Greece, Japan, South Korea and Puerto Rico, to 24.9% in Austria (Fig. 1). It can be seen from Figure 1 that, of the four countries with the highest rate of MC fitting to children, three were Germanic countries – namely, Austria, Germany and Switzerland. This is also evident in Fig. 2, which is a color-coded ‘heat map’, showing the extent of MC fitting around the world.

3.3 Trends over time

The **proportion** of MC contact lens fitting to children has risen through the eight year survey period ($\chi^2 = 203$, $p < 0.0001$), increasing from 0.2% of all lens fits in 2011 to 6.8% in 2018.

Figure 3 shows the change in soft and rigid MC fits to children as a proportion of all soft and rigid lens fits, respectively. Evident in this figure is the sharp increase, especially over the last three years of this survey (2016 to 2018), in extent of rigid lens fits for MC as a proportion of all rigid lens fits.

3.4 Patient age

The distribution of MC and non-MC lens fits, stratified by age, is presented in Fig. 4. It is evident from inspection of this plot that the distribution of MC fits is skewed towards a younger age than the distribution of non-MC fits; this difference is statistically significant ($\chi^2 = 69$, $p < 0.0001$). The median age of MC and non-MC fits is 13 and 15 years, respectively. Most MC fitting activity appears to be taking place among children aged 8 to 15 years.

3.5 Sex

There was no significant difference in the proportion of females fitted with MC lenses (58.1%) versus those fitted with non-MC lenses (62.3%) ($\chi^2 = 0.02$, $p = 0.89$).

3.6 Lens type

The conduct of this survey precluded a precise determination of the lens designs used for MC; however, it is assumed that essentially all rigid lenses fitted for MC to children were orthokeratology designs and all soft lenses fitted for MC were centre-distance multifocal designs.

Of all contact lenses fitted for the purpose of MC to children, 52.1% were undertaken using rigid lenses; this compares with 12.0% for non-MC fits with rigid lenses ($\chi^2 = 143$, $p < 0.0001$).

3.7 Frequency of lens wear

The frequency of lens wear was 6.7 ± 0.9 days per week for MC fits versus 5.8 ± 1.7 days per week for non-MC fits ($\chi^2 = 116$, $p < 0.0001$). Lenses were worn 7 days per week by 84% of children fitted with MC lenses versus 56% of children fitted with non-MC lenses.

3.8 Differences within MC group

Differences found between children for the two main types of MC lenses fitted were not statistically significant. Median age was similar for the two lens types (12 years for children using rigid lenses for MC versus 13 years for children wearing soft lenses) ($Z = 1.8$, $p = 0.08$). The difference in breakdown for sex (54% female in those wearing rigid lenses and 60% female among soft lens wearers) was also not significant ($\chi^2 = 2.1$, $p = 0.14$).

4. Discussion

International differences in the extent of contact lens fitting for MC may be attributed to a number of factors. Throughout the period of this survey, the MiSight lens (CooperVision, USA) [14] was the only soft lens specifically approved for the indication of MC. This lens was not available in all

171 countries surveyed, but was introduced into some countries at different stages throughout the 8-year
172 course of the work; at the time of writing, the MiSight lens was available in only 14 of the 31
173 countries surveyed (see Figure 1). Nevertheless, some practitioners appear to have elected to
174 prescribe ‘off label’ lens designs licensed to correct presbyopia, for the purposes of MC in children;
175 the present data confirm this, as a number of countries where MiSight was not available at any stage
176 during the survey period reported soft lens use for MC in children. Regardless, increased fitting for
177 MC would be expected to be observed in those countries in which the MiSight lens was available,
178 and moreso where the MiSight lens was introduced earlier.

179
180 International differences in the training, attitudes and collective confidence of the predominant eye
181 care practitioner groups – opticians, optometrists and ophthalmologists – and the proportion of
182 practitioner type in different regions, may also impact the extent of contact lens MC fitting between
183 countries. For example, there may be a higher rate of prescribing of low dose atropine, and a
184 commensurate lower prescribing rate of contact lenses, in regions with a high proportion of
185 ophthalmologists or therapeutically-endorsed optometrists.

186
187 An unexpected finding of this survey was the relatively high rate of MC prescribing for children in
188 the Germanic countries of Austria, Germany and Switzerland. This may be attributed to two factors:
189 (1) the traditional high prescribing rate of rigid lenses in central Europe and the commensurate
190 possession of advanced rigid lens fitting skills set among European practitioners (compared to
191 Asia), who are capable of fitting orthokeratology rigid lenses for MC and have ready access to
192 specialised local rigid lens laboratories who can supply such lenses, coupled with (2) the
193 availability of the MiSight lens for MC in these three countries. Highest rates of MC prescribing
194 might have been predicted to be observed in parts of east and southeast Asia in view of the well-
195 documented myopia epidemic in this region [11]. Perhaps difficulties in obtaining regulatory
196 approval in some Asian markets (e.g. Japan) have served to constrain MC fitting in this region.

197
198 Overall, MC represented only 2.3% of all contact lens fits, notwithstanding the gradual increase in
199 MC fitting throughout the survey period. Three factors that may have limited the uptake of contact
200 lenses for MC are (1) the lack of on-label MC products for most of the survey period and in most
201 parts of the world; (2) reservations and uncertainty as to the true efficacy of MC fitting [15], and (3)
202 an apparent lack of awareness among parents of myopic children of the ocular health risks of
203 myopia development and the potential benefits of MC [16]. Nevertheless, the gradual increase in
204 MC fitting over the course of this survey possibly reflects a growing awareness among eye care
205 practitioners of the importance of arresting myopia progression where possible [17].

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The skewed age distribution of MC fits towards younger children as observed in this study is consistent with the notion that MC lenses should be prescribed at the earliest possible sign of myopia development [18].

Despite the higher prevalence of myopia among Caucasian and East Asian adolescent females [19], no difference was observed in the proportion of females fitted with MC versus non-MC lenses in the present study. The reason for the apparent under-representation of females is unclear; one possible explanation is that a higher proportion of females is being treated using alternative MC strategies, such as low-dose atropine.

Although rigid lenses specifically approved for MC were not available during the survey period, the high rate of rigid lens fitting for MC (compared with non-MC rigid lens fits) – which are essentially orthokeratology lens fits – may be due to a number of factors: (1) the possession of high levels of orthokeratology lens fitting skills in some regions, as discussed above; (2) the ready availability of local laboratories able and willing to supply appropriate orthokeratology designs for MC fitting; and (3) the belief among some practitioners that orthokeratology is more efficacious than soft lens fitting for MC.

That MC lenses are worn about one day per week more than non-MC lenses is consistent with the higher rate of rigid (orthokeratology) lens fits for MC versus non-MC. Orthokeratology lenses must be worn every night to maintain the daily corneal moulding effect required to improve vision [20]. Also, rigid lenses are not conducive to intermittent lens wear; it is well accepted that full-time lens wear helps maintaining lens adaptation, thus enhancing day to day comfort [21]. The higher frequency of lens wear for MC compared to that for non-MC may also relate to a perception, in the absence of any direct evidence, that MC is dose-dependent, i.e. the more such lenses are worn, the greater is the efficacy of the procedure for arresting myopia progression.

No clear differences were seen the demographics of children fitted with soft lenses versus rigid lenses for MC. This is unsurprising for the breakdown in sex between the two lens types, but it is also informative that there is no clear trend at this time for practitioners to select a soft lens in younger MC patients on the basis that this might be a simpler or more familiar option for a potentially challenging patient population.

240 Sampling bias is perhas the greatest limitation of this study. In many contries investigated, survey
241 distribution is not completely random; for example, in many instances, surveys are sent to known
242 groups of practitioners with a special interest in contact lenses (as distinct from ‘general’ eye care
243 practitioners). Therefore, this could result in a bias towards the survey data reflecting the
244 prescribing data of those with a particular interest in contact lens prescribing. Also, it is assumed
245 that survey respondents have reported accurately; the nature of the study is such that it has not been
246 possible to audit the submitted data. Despite these limitations, the clear, consistent and intuitively
247 plausible trends observed in respect of numerous parameters assessed suggests that the data set is
248 robust.

249

250 **5. Conclusions**

251 Contact lens fitting to arrest the progression of myopia in children is one of a number of viable
252 strategies available for fighting the myopia epidemic. This approach has been adopted by eye care
253 practitioners in many nations over the past eight years at a relatively low level, although there is
254 evidence of a gradual increased MC fitting over time. Rigid lenses (primarily orthokeratology) and
255 soft lenses (primarily centre-distance multifocals) are being fitted for MC to children in
256 approximately equal measure. Children being fitted with MC lenses are younger than those being
257 fitted with non-MC lenses.

258

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263 Aighamdi, Saudi Arabia; Suresh Awasthi, Nepal; Joseph Barr, United States of America; Marion
264 Beeler-Kaupke, Switzerland; Jitka Belikova, The Czech Republic; Vadim Belousov, Russia; Jolanta
265 Bendoriene, Lithuania; Janet Casablanca, Puerto Rico; Aris Chandrinos, Greece; Prema Chande,
266 India; Patrick Cheng, Hong Kong; JhoYan Chia, Malaysia; Byoung Sun Chu, South Korea; Edgar
267 Dávila-Garcia, Puerto Rico; Nir Erdinest, Israel; Chi Shing Fan, Asia-Pacific; Philip Fine, Israel;
268 Peter Gierow, Sweden; José Manuel González-Méijome, Portugal; Martha Yanneth Gonzalez,
269 United States of America; Hans-Jürgen Grein, Germany; Christina N Grupcheva, Bulgaria; Jörgen
270 Gustafsson, Sweden; Magne Helland, Norway; Anna Yeo Chwee Hong, Singapore; Hreinn Ingi
271 Hreinsson, Iceland; John Hsiao, Taiwan; Lee Kai Hung, Singapore; Motozumi Itoi, Japan; Ali Reza
272 Jafari, Iran; Oskar Johansson, Sweden; Deborah Jones, Canada; Lyndon Jones, Canada; Razmig
273 Knajian, United Arab Emirates; Jitka Krasnanska, The Czech Republic; Wanda Lam, New Zealand;
274 Weizhong Lan, China; Rafael S. Lemos, Brazil; Weronika Leszczyńska, Poland; Carla J Mack,

275 United States of America; Patricia Magnelli, Argentina; Florence Malet, France; Edoardo Marani,
 276 Italy; Sebastian Marx, Germany; Nelson L. Merchan, Colombia; Giancarlo Montani, Italy; Jose L.
 277 Moroy, Mexico; Vishakh Nair, Saudi Arabia; Alex Ong, Singapore; Guillermo Carrillo Orihuela,
 278 The Americas; Alice Pesinova, The Czech Republic; Anna Lindskoog Pettersson, Sweden; Geraint
 279 Phillips, New Zealand; Ricardo Pintor, Mexico; Athina Plakitsi, Greece; Heiko Pult, Germany; Polo
 280 Qi, China; Simona Radu, Romania; Jona Birna Ragnarsdóttir, Iceland; Hrvoje Raguž, Croatia; Raul
 281 L Ramos Gómez; Ole Ravn, Denmark; Jeanette Romualdez-Oo, The Philippines; Svend-Erik
 282 Runberg, Denmark; Mirna Stabuc Silih, Slovenia; Danny Sim, Singapore; Leon Sze, Hong Kong;
 283 Kah-Ooi Tan, China; Panu Tast, Finland; Mario Teufl, Austria; Inga-Lill Thunholm-Henriksson,
 284 Sweden; Ioannis G Tranoudis, Greece; Marco van Beusekom, The Netherlands; Eef van der Worp,
 285 The Netherlands; Mihály Végh, Hungary; Edit Vodnyanszky, Hungary; Ann Elisabeth Ystenæs,
 286 Norway; and Veronica Ziziuchin, Moldova.

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Figure Legends

351

352 Fig. 1. Proportion all contact lenses fitted for MC to children in 31 countries between 2011
353 and 2018. Error bars represent the positive 95% confidence limit. AT Austria*, AU
354 Australia*; BG Bulgaria; CA Canada*; CH Switzerland*; CZ Czech Republic; DE
355 Germany*; DK Denmark*; ES Spain*; FR France*; GR Greece; HK Hong Kong*;
356 HU Hungary; IL Israel; IT Italy; JP Japan; KR South Korea; LT Lithuania; MX
357 Mexico, NL Netherlands*; NO Norway*; NZ New Zealand; PH Philippines; PR
358 Puerto Rico; PT Portugal*; RU Russia; SE Sweden*; SI Slovenia; TW Taiwan; UK
359 United Kingdom*; US United States. *MiSight lens available at time of writing.

360

361 Fig. 2. ‘Heat map’ indicating the extent of MC lens fitting to children in different countries
362 around the world. Note the logarithmic colour-coded scale. Nations shown in white
363 (no colour) were not surveyed.

364

365 Fig. 3. Trend in the proportion of soft and rigid MC fits to children as a proportion of all soft
366 and rigid lens fits, respectively, in 31 countries between 2011 and 2018. Error bars
367 represent the 95% confidence limit.

368

369 Fig. 4. Age categories of children fitted with contact lenses for MC, and for children fitted
370 with all other lens types (non-MC), in 31 countries between 2011 and 2018.

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TABLE 1

Information captured about each patient fitted.

Information category	Options
Date of fitting	(day/month)
Age	(in years)
Sex	Male Female
Type of fit	New fit Refit
Rigid lens material/type	Scleral PMMA Dk < 40 Dk 40-90 Dk > 90
Soft lens materials	Conventional hydrogel < 40% water Conventional hydrogel 40-60%water Conventional hydrogel > 60% water Silicone hydrogel
Lens design	Sphere Toric Multifocal Monovision Cosmetic tint Orthokeratology Myopia control Other
Frequency of replacement	Daily 1-2 weeks 1 month 3-6 months 12 months Unplanned
Times per week of wear	1-7
Modality	Daily wear Extended wear
Care system	Multipurpose Peroxide Other None

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