A new look at the myopia control efficacy of orthokeratology

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Financial disclosure: JS-R is a full-time employee of Menicon Co. Ltd

Purpose

The efficacy of orthokeratology (OK) contact lens wear in slowing myopia progression in myopic children is well established. However, it is unclear whether such efficacy is affected by factors such as the subject's age, gender, ethnicity and mean spherical refractive error (MSRE) at baseline. Furthermore, little is known about the proportion and characteristics of wearers showing different levels of myopia control efficacy. Pooling together data from three prospective studies[1-3] this study reports on the effect of age, gender, ethnicity and MSRE on the efficacy of OK lens wear in slowing myopia progression. Additionally, this study also reports on a new methodology that identified proportions of subjects and characterized subgroups of ok lens wearers who experienced different levels of myopia control efficacy.

Methods

- Data from three prospective studies,[1-3] which evaluated the use of OK for slowing myopia progression in children in comparison to a parallel control group of distance, single-vision spectacle lens wearers (CT) over a 2-year period, were pooled together for analysis.
- The primary pooled efficacy endpoint is the absolute, cumulative, reduction in the axial elongation of the eye in the OK group in comparison to the CT group over a 2-year period. In all the three studies, measures of axial length were recorded at baseline and then at a minimum of 6-month interval over the 2-year period using the same instrument (Zeiss IOLMaster, Zeiss Humphrey Systems, Dublin, CA).
- A repeated-measures ANOVA (and unpaired t-tests with Bonferroni corrections where appropriate) was used to test differences in axial length relative to baseline between groups. Type of refractive correction (i.e., OK vs. single-vision spectacles) was designated the factor of interest and time the repeated measure. Subjects' age, gender, MSRE and ethnicity (i.e., Hong Kong Chinese vs. White European) were tested as covariates.
- Orthokeratology lens wearers who experienced different levels of myopia control efficacy were further classified based on changes in axial length.

Results

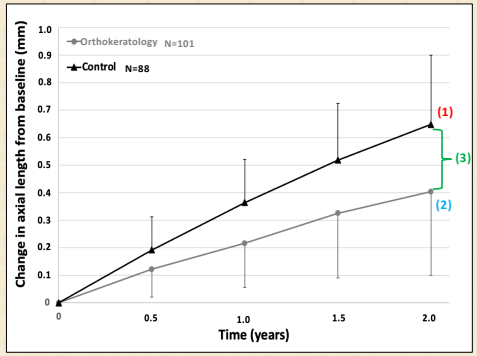
Collectively, the three studies enrolled 125 OK and 118 CT subjects. Of these, 101 (81%) and 88 (75%) OK and CT subjects completed the 2-year follow-up period, respectively. No significant differences were found between groups in baseline demographics (Table 1).

Table 1. Baseline demographics of subjects who completed the 2-year follow-up period. N, number of subjects; MSE, mean spherical refractive error; D, dioptres; HK, Hong Kong Chinese; WE, White European. Variables are expressed as mean ± standard deviation.

	Orthokeratology N=101	Control N=88	Statistical significance (p-value)
Age (years)	9.12 ± 1.36	9.16 ± 1.43	0.973
Male/female ratio	51/50	43/45	0.823
Ethnicity ratio (HK/WE)	72/29	64/24	0.826
MSE (D)	-2.70 ± 1.20	-2.55 ± 1.06	0.723
Axial length (mm)	24.43 ± 0.79	24.29 ± 0.92	0.256

Statistically significant differences in the change in axial length from baseline were found over time, between groups and for the time*group interaction (all p<0.001), indicating that although there was an overall increase in axial length over time in both groups, the rate of increase in axial length over time in the OK group was significantly lower in comparison to the CT group (Figure 1). The lower axial elongation of the OK group in comparison to the CT group was statistically significant at all time points (all p<0.001), with significant differences being also present between each of the different pairs of time points (all p<0.001). The interactions of time with age and ethnicity were significant indicating that younger and Hong Kong Chinese children experienced greater axial elongation in comparison with older and White European subjects, respectively (both p<0.001). However, as the interactions of group with age, gender, MSRE and ethnicity at baseline were not significant (all p>0.05), they were removed from the model.

Figure 1. Mean axial length changes (from baseline) ± standard deviation for the orthokeratology and control groups . Error bars represent one standard error of the mean.



At 12 months, the mean change in axial length (± standard deviation [SD]) in comparison to baseline was 0.37 ± 0.16 mm (95% confidence intervals [CI]: 0.33 to 0.40 mm) in the CT group vs. 0.22 ± 0.16 mm (95% CI: 0.18 to 0.25 mm) in the OK group, representing an average of 0.15 mm (95% CI: 0.06 to 0.24 mm) less growth in the OK group. The change in axial length (± SD) at the 2-year visit in comparison to baseline for the CT and OK groups were: **(1) 0.65 ± 0.30 mm (95% CI: 0.59 to 0.71 mm)** and **(2) 0.41 ± 0.25 mm (95% CI: 0.35 to 0.45 mm)**, respectively, thus OK lens wear provided an absolute, accumulative **treatment effect following 2-years of lens wear of (3) 0.24 mm (95% CI: 0.15 to 0.34 mm)** in comparison to the CT group. The latter results indicate that 62.5% of the 2-year treatment effect was obtained during the first year of treatment.

Quantifying different levels of myopia control efficacy

An axial length change ≤0.02mm was considered a lack of myopia progression. Eight OK subjects (7.9%) showed no myopia progression (axial elongation ≤0.02mm) (**Table 2**). In contrast, 25 OK subjects (24.8%) showed 2-year changes in axial length falling over the lower 95% CI of the 2-year change in axial length from the CT group (i.e., 0.59 mm) indicating that OK was ineffective in slowing myopia progression in these wearers (**Table 2**). In-between OK subjects that either experienced no axial elongation (n=8) or levels of axial elongation equivalent to that found in the CT group (n=25) there were 68 subjects that experienced some slowing of axial elongation; the 25-, 50- and 75-percentiles of the 2-year change in axial length for this latter subgroup were 0.24, 0.37 and 0.45 mm, respectively. These latter values were used to classify subjects into high (>0.02 to ≤0.24mm), moderate (>0.24 to ≤0.37mm) and low (>0.37 to ≤0.59mm) levels of myopia control efficacy (**Table 2**).

Myopia Control Efficacy (2-years' AL change)	N (%)*	Ethnicity: HK/WE (%)*	Sex: M/F (%)*	Mean age ± SD (years)	MSRE ± SD (D)	Mean 24-months change in AL ± SD (mm)
Full (≤0.02mm)	8 (7.9%)	7.9/0	2.9/4.9	9.63 ± 0.74	-3.39 ± 1.56	-0.07 ± 0.11
High (>0.02 to ≤0.24mm)	18 (17.8%)	17.8/10.3	10.9/6.9	9.46 ± 1.65	-3.03 ± 1.47	0.15 ± 0.06
Moderate (>0.24 to ≤0.37mm)	16 (15.8%)	8.9/24.1	8.9/6.9	8.88 ± 1.54	-1.98 ± 0.80	0.32 ± 0.04
Low (>0.37 to ≤0.59mm)	34 (33.7%)	23.8/34.5	11.9/21.8	9.50 ± 1.21	-2.56 ± 1.09	0.46 ± 0.05
None (>0.59 mm)	25 (24.8%)	15.8/31.0	15.8/8.9	8.28 ± 0.94	-2.57 ± 1.03	0.72 ± 0.11

Table 2. Number and baseline characteristics of subgroups of orthokeratology lens wearers with different levels of myopia control efficacy as per axial length changes at the 24-month visit in comparison to baseline. AL, axial length; N, number of subjects within each orthokeratology subgroup; *(percentage over the total number of subjects in the orthokeratology group (i.e., 101)); HK, Hong Kong Chinese; WE, White European; M, male; F, female; SD, standard deviation; MSER, mean spherical equivalent refractive error; D, diopters.

Comparison between OK subjects who experienced no axial elongation (axial elongation ≤0.02mm) vs. those with axial elongation equivalent to the CT group (axial elongation >0.59mm) (**Table 2**) revealed significant differences in age (p<0.001) and ethnicity (p=0.047), but not in gender (p=0.187) and MSRE (p=0.093). Thus, in terms of slowing axial elongation, OK appears to more efficacious in older, Hong Kong Chinese subjects and less efficacious in younger, white European subjects.

Discussion/Conclusions

- The 2-years effect size (i.e., 0.24 mm) is remarkably similar to that reported in meta-analyses, but higher than that reported with most soft contact lenses used for myopia control.
- The 1st year treatment effect was over 60% of that found in the 2nd year; this appears to be a common feature among different myopia control treatments.
- The interactions of group with age, gender, MSRE and ethnicity at baseline were not significant. However, comparison between subgroups of OK subjects showing full myopia control efficacy (axial elongation ≤0.02mm) vs. those that showed no myopia control efficacy (axial elongation >0.59mm) revealed that, in terms of slowing myopia progression, OK might work best in older, Hong-Kong Chinese subjects and worst in younger, white European subjects (**Table 2**).
- A quarter of OK subjects experienced remarkably low levels of myopia progression, with 8% showing a full arrest of myopia progression. In contrast, another quarter of wearers showed levels of axial elongation equivalent to of the control group (2-years axial elongation: >0.59mm) indicating that lens wear does not work for myopia control in this subgroup (**Table 2**).
- A limitation of this study is that subjects were randomized to treatment in just one of the studies.[1] Likewise, only one study used a single-masked study design (i.e., investigator-masked).[1] Nonetheless, randomization makes difficult recruitment due to parents not wanting their child to risk receiving the placebo, and whereas investigator masking is difficult, masking subjects to wear either OK or spectacles is not possible.
- A strength of this study is that all three studies employed almost identical study designs in that they were prospective clinical trials designed to assess the clinical performance of the same OK contact lens (i.e., Menicon Z Night) in slowing the axial elongation of the eye in myopic children. Both study groups were well balanced as no significant differences were found between groups in any of the baseline demographics. The relatively large sample size employed allowed for the assessment of the effect of age, gender, ethnicity and MSRE, as well as for the analyses and comparisons of subgroups of OK lens wearers who experienced different levels of axial elongation.
- In conclusion, OK lens wear slowed the axial elongation of the eye by 0.24 mm in comparison to spectacle lens wearers over a 2-year period, with over 60% of the treatment effect being obtained during the first year of treatment. Around 25% of OK lens wearing subjects showed very low levels of myopia progression, with an 8% showing no axial elongation or a shrinkage in axial length. In contrast, another quarter of orthokeratology subjects did not appear to benefit from lens wear for slowing myopia progression. These results inform eye care practitioners as to what sort of myopia control efficacy can be expected when OK lenses are prescribed for slowing myopia progression to myopic children.

References

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