



Vision-related quality of life of Chinese children undergoing orthokeratology treatment compared to single vision spectacles

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ABSTRACT

Objective: To measure and compare the vision-related quality of life between Chinese children wearing orthokeratology (ortho-k) lenses and single vision spectacles, to understand acceptance of ortho-k treatment by children in China.

Methods: Subjects of Chinese origin, with myopia of -5.00 to -0.75 D, astigmatism < 1.50 D were recruited. All subjects had been wearing optical correction – ortho-k lenses or single vision spectacles (SVS), for the past 12–18 months and were aged between 8–12 years. The Pediatric Refractive Error Profile (PREP) questionnaire, translated to Chinese, was used to evaluate the perceptions of children wearing spectacles in overall vision, near vision, far vision, symptoms, appearance, satisfaction, activities, academic performance, handling of optical corrections, and peer perceptions. PREP questions, rephrased to address the same issues for ortho-k subjects who did not wear spectacles in the daytime, were used for ortho-k wearers (PREP-OK). The mean score of all items was calculated as the overall score. For ortho-k wearers, four additional questions on experience and frequency of symptoms: experiencing difficulty in falling asleep, ocular discomfort, itchy/burning/dry eyes, and foreign body sensation during ortho-k lens wear at night were asked and reported separately.

Results: Forty subjects (20 ortho-k, 20 SVS) completed the study. Overall vision, far vision, appearance, satisfaction, activities, and peer perception scores in the ortho-k group were significantly better than the SVS group (all $P < 0.05$). Handling of optical correction score in the ortho-k group was significantly worse than the SVS group ($P = 0.04$). No significant differences in near vision, symptoms in the daytime and academic performance were found between two groups ($P > 0.05$). With respect to symptoms during ortho-k lens wear at night, none of the subjects reported difficulty in falling asleep, but 30–40 % of subjects reported occasional ocular discomfort, itchy/burning/dry eyes, and foreign body sensation after lens insertion.

Conclusion: Although ortho-k may induce some ocular discomfort with lens wear during the night, these were infrequent and the benefits from ortho-k can compensate for the discomfort, leading to better vision-related quality of life in Chinese children, compared with those wearing SVS.

1. Introduction

As ortho-k has been shown to be an effective optical intervention in slowing myopic progression in children [1–7], it has been increasingly accepted by these children and their parents, especially in East Asian countries, including China. The Pediatric Refractive Error Profile (PREP) questionnaire has been specifically designed to assess children's vision-related quality of life (VRQoL) and is a sensitive questionnaire for detecting differences between children wearing different vision aids [8–10]. Significant improvements in VRQoL have been reported in

children wearing soft contact lenses compared to children wearing single vision spectacles (SVS), particularly in areas related to limitations in activity, appearance, athletics, and satisfaction with the correction [8–13].

No significant difference was observed in the benefit profile of children and teenagers, in whom the overall PREP score improved significantly 1-week after commencement of soft contact lens wear, and remained stable throughout the study period [8]. Comparison of the VRQoL scores in adults wearing soft contact lenses and ortho-k lenses revealed that the overall satisfaction and vision were comparable [14].

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However, about 68 % of these subjects chose to continue ortho-k lenses wear at the end of their study, as these lenses were worn only while sleeping and subjects enjoyed daytime correction-free vision. Ortho-k subjects also reported far fewer symptoms, such as itching, burning, and dryness. However, soft lens wearers tended to notice less glare compared to ortho-k subjects. Using the PREP questionnaire, Santodomingo-Rubido et al. [15] compared the VRQoL between children wearing ortho-k lenses and SVS and found that the scores of most items, except near vision and handling in children wearing ortho-k lenses were significantly better than children wearing SVS. There were apparent fluctuations in the scores during the first three months of contact lens wear, but they stabilized thereafter.

Contact lens wear for vision correction in the daytime is not popular among children in East Asian countries, except for special cases where SVS could not achieve good vision correction, for example, in cases of high astigmatism or high anisometropia [16]. Parents and optometrists are concerned about the capability of children to handle and care for contact lenses, leading to reluctance to use contact lenses as a treatment option for refractive error in children [17]. However, ortho-k is now widely used in China for myopia control in children [18]. The prevalence of myopia in children is high in China and the market for myopia control, specifically ortho-k, is growing rapidly, as more and more parents realize the importance of myopia control. Low-concentration atropine eye drops have not been officially approved for myopia control by China Food and Drug Administration and other optical myopia control treatments, such as soft multifocal lenses for myopia control and special-designed spectacles are either not available, or have just been introduced and have not gained popularity yet in China. Ortho-k is therefore widely used in China and considered the most effective optical correction for myopia control. However, few studies have focused on the effects on quality of life in these children compared to those wearing SVS in China. Zhao et al. [19], using a different questionnaire, "Quality of Life Impact of Refractive Correction (QIRC)," on Chinese children before and after ortho-k wear for three months reported that ortho-k had a good effect on children's quality of life and behaviors. However, no previous studies have investigated the VRQoL between Chinese children wearing ortho-k and SVS using PREP. Therefore, this study aimed to evaluate and compare the VRQoL between children wearing ortho-k lenses and SVS in a Chinese population, in order to understand their acceptance of ortho-k treatment.

2. Materials and methods

2.1. Subjects

This was a retrospective cohort study. Subjects were patients of Chinese origin, aged 8–12 years, with myopia of -5.00 to -0.75 D, astigmatism (with-the-rule) < 1.50 D, best corrected monocular logMAR visual acuity 0.0 or better, no abnormal ocular conditions, and who had been wearing ortho-k lenses (at least 8 h per night) or SVS for the last 12–18 months. They were recruited randomly from the Contact Lens Clinic and Myopia Clinic of the West China Hospital, when they came back for routine aftercare/follow-up visit.

The study followed the tenets of the Declaration of Helsinki and was approved by the ethics committee of the West China Hospital, Chengdu. Informed consent was obtained from both the children and their parents after verbal and written explanation of the study. Subjects were asked to complete the questionnaire on site after their routine eye examination.

2.2. Sample size

Sample size calculation was based on the mean and SD of overall vision scores for soft contact lens and SVS groups in a previous study which used the PREP questionnaire to examine the benefits of contact lens wear for children [8]. To achieve a power of 90 % with a significance level of 0.05, a sample size of at least 28 was required.

2.3. The vision-related quality of life survey

The original PREP questionnaire (Table 1), translated to Chinese, was validated by forward and backward translation between English and Chinese by two bilingual translators with no prior familiarity with this study. The translations were then reviewed again by the investigator to ensure cultural and vocabulary adaptation. This was used for SVS subjects. For the ortho-k subjects, the questionnaire was minimally modified (PREP-OK) by substituting the word/clause 'glasses'/'When I wear my glasses' with 'ortho-k'/'After I wore ortho-k lenses' to address exactly the same issues (Table 2). The same 26 questions on overall vision, near vision, far vision, symptoms in the daytime, appearance, satisfaction, activities, academic performance, handling of optical corrections, and peer perceptions were used for both questionnaires.

Subjects (children) were asked to read the 26 statements in the questionnaire and mark "strongly agree," "agree," "neutral," "disagree," or "strongly disagree," according to their subjective feeling. Following the instructions for PREP questionnaire [8,10,13,15], each statement was scored from 5 (positive) to 1 (negative) and then scaled from 100 (excellent quality of life) to 0 (poor quality) by subtracting 1 from the raw score of each question and multiplying by 25, and the overall PREP score was the average of all 26 statements.

Ortho-k subjects were also asked to respond to four additional questions (Table 3. Questions a–d) about symptoms during ortho-k lens wear at night using the same scale of 1–5 (1 (strongly agree) - 5 (strongly

Table 1
PREP questionnaire [8] for subjects wearing spectacles in the daytime.

Overall vision(daytime)
Q1. When I wear my glasses, I have problems seeing clearly. ^a
Q2. When I wear my glasses, my vision is very clear.
Q3. When I wear my glasses, my vision is blurry. ^a
Near vision(daytime)
Q4. When I wear my glasses, I have no problems seeing the computer or video games.
Q5. When I wear my glasses, I have problems reading. ^a
Far vision(daytime)
Q6. When I wear my glasses, I am able to see clearly far away.
Q7. When I wear my glasses, I have problems seeing at the movies or when I look far away. ^a
Symptoms(daytime)
Q8. When I wear my glasses, my eyes hurt. ^a
Q9. When I wear my glasses, my nose, ears or head hurts. ^a
Q10. When I wear my glasses, my eyes itch, burn, or feel dry. ^a
Q11. When I wear my glasses, my eyes feel good.
Appearance(daytime)
Q12. When I wear my glasses, I like how I look.
Q13. I don't like how I look with glasses. ^a
Q14. If I wore orthokeratology lenses, I would look better. ^a
Satisfaction
Q15. I like to wear my glasses.
Activities(daytime)
Q16. I never have a problem wearing my glasses when I play outdoors.
Q17. I am bothered by my glasses when I play sports, dance or do other activities. ^a
Academics(daytime)
Q18. When I wear my glasses, I do better at school.
Q19. When I wear my glasses, I do better on tests.
Handling
Q20. It is easy to clean and take care of my glasses.
Q21. It is easy to put on/in and take off/out my glasses.
Q22. My glasses get lost or broken easily. ^a
Q23. My glasses fall off my face. ^a
Peer perceptions
Q24. When I wear my glasses, my friends make fun of me. ^a
Q25. When I wear my glasses, my friends want to wear glasses, too.
Q26. When I wear my glasses, my friends like the way I look.

Each statement was scored from 5 (positive) to 1 (negative) and then scaled from 100 (excellent quality of life) to 0 (poor quality) by subtracting 1 from the raw score of each question and multiplying by 25, and the overall PREP score was the average of all 26 statements [8].

^aStatements that are reverse-coded, so that "strongly disagree" corresponds to 5 points.

Table 2

PREP questionnaire [8] for subjects wearing orthokeratology lenses at night (PREP-OK questionnaire).

Overall vision(daytime)	
Q1. After I wear my orthokeratology lenses, I have problems seeing clearly. ^a	
Q2. After I wear my orthokeratology lenses, my vision is very clear.	
Q3. After I wear my orthokeratology lenses, my vision is blurry. ^a	
Near vision(daytime)	
Q4. After I wear my orthokeratology lenses, I have no problems seeing the computer or video games.	
Q5. After I wear my orthokeratology lenses, I have problems reading. ^a	
Far vision(daytime)	
Q6. After I wear my orthokeratology lenses, I am able to see clearly far away.	
Q7. After I wear my orthokeratology lenses, I have problems seeing at the movies or when I look far away. ^a	
Symptoms(daytime)	
Q8. After I wear my orthokeratology lenses, my eyes hurt. ^a	
Q9. After I wear my orthokeratology lenses, my nose, ears or head hurts. ^a	
Q10. After I wear my orthokeratology lenses, my eyes itch, burn, or feel dry. ^a	
Q11. After I wear my orthokeratology lenses, my eyes feel good.	
Appearance(daytime)	
Q12. After I wear my orthokeratology lenses, I like how I look.	
Q13. I don't like how I look after I wear my orthokeratology lenses. ^a	
Q14. If I wore glasses, I would look better. ^a	
Satisfaction	
Q15. I like to wear my orthokeratology lenses	
Activities(daytime)	
Q16. I never have a problem when I play outdoors after I wear my orthokeratology lenses.	
Q17. I am bothered by my eye when I play sports, dance or do other activities after wearing after I wear my orthokeratology lenses. ^a	
Academics(daytime)	
Q18. After I wear my orthokeratology lenses, I do better at school.	
Q19. After I wear my orthokeratology lenses, I do better on tests.	
Handling	
Q20. It is easy to clean and take care of my orthokeratology lenses.	
Q21. It is easy to put on/in and take off/out my orthokeratology lenses.	
Q22. My orthokeratology lenses get lost or broken easily. ^a	
Q23. My orthokeratology lenses fall off my face. ^a	
Peer perceptions	
Q24. After I wear my orthokeratology lenses, my friends make fun of me. ^a	
Q25. After I wear my orthokeratology lenses, my friends want to wear orthokeratology lenses, too.	
Q26. After I wear my orthokeratology lenses, my friends like the way I look.	

Each statement was scored from 5 (positive) to 1 (negative) and then scaled from 100 (excellent quality of life) to 0 (poor quality) by subtracting 1 from the raw score of each question and multiplying by 25, and the overall PREP score was the average of all 26 statements [8].

aStatements that are reverse-coded, so that "strongly disagree" corresponds to 5 points.

Table 3

Additional questions for symptoms during orthokeratology lens wear at night.

- I find it hard to fall asleep.^a(How often?)
- I experience eye discomfort.^a(How often?)
- My eyes itch, burn, or feel dry.^a(How often?)
- I feel strong foreign body sensation.^a(How often?)

Each statement was scored from 5 (positive) to 1 (negative).

aStatements that are reverse-coded, so that "strongly disagree" corresponds to 5 points.

disagree)) and the scores recorded and reported independently, without scaling to 100. The number (percentage) of subjects with scores > 3 (disagree/strongly disagree) or ≤ 3 (neutral-agree) on symptoms during ortho-k wear at night and number of subjects reporting different frequencies of the symptoms were described separately.

The questionnaire was administered by an optometrist who did not participate in the data analysis.

2.4. Statistical analysis

Statistical analysis was performed using SPSS (IBM SPSS Statistics

22; SPSS Inc., Monk, NY). Normality of data was determined using the Kolmogorov-Smirnov test. Mean and SD were reported for normally distributed data while median and range were reported for non-normally distributed data. Unpaired *t*-test was used for normally distributed data, while Mann-Whitney test was used if data did not follow a normal distribution. Chi-Square test was used for gender comparison. For all analyses, *P* < 0.05 was considered significant. The reliabilities of the PREP questionnaire and PREP-OK questionnaire used were analyzed by Cronbach's Alpha reliability analysis.

3. Results

Forty subjects (20 using ortho-k and 20 SVS) were recruited for the study between March 2019 and June 2019. Table 4 shows a summary of the characteristics and baseline data of the two groups of subjects. No significant differences in the demographic and baseline data were found between the two groups (*P* > 0.05).

Table 5 shows the PREP scores of the 26 items for the two groups. There were no significant differences in near vision, symptoms in the daytime, and academic scores between the two groups (*P* = 0.10, 0.37 and 0.58, respectively). Overall vision, far vision, appearance, satisfaction, activities, peer perception, and overall scores in the ortho-k group were significantly higher than for the SVS group (all *P* < 0.05). However, the handling of optical correction score in the ortho-k group was significantly lower than for the SVS group (*P* = 0.04).

Although multiple tests were performed on the same data set, Bonferroni corrections were not considered to be necessary, as the outcomes were specified a priori and were likely to correlate with one another [20]. According to Streiner [20], correcting for multiplicity in such cases may be judged to be unnecessary and counterproductive. (As shown in Table 5, most of the statistically significant items had *P* < 0.0001, in which case Bonferroni correction would be moot. The remaining three items, Handling (*P* = 0.04), Peer Perception (*P* = 0.02) and Far VA (*P* = 0.03) all showed effects that were consistently in the same direction.

Note that the same statistical results were obtained if original scores (i.e. without scaling to 100) were analyzed.

For the original PREP questionnaire, the Cronbach's Alpha was 0.81. The Cronbach's Alpha for the split halves of original PREP questionnaire was 0.78 and 0.71 respectively. For the PREP-OK, the Cronbach's Alpha was 0.75. The Cronbach's Alpha for the split halves of PREP-OK was 0.71 and 0.71 respectively.

Table 6 presents a summary of the results of symptoms experienced by ortho-k subjects. None of the subjects experienced difficulty in falling asleep with ortho-k lens wear, although 6–8 subjects (30–40 %) reported one or more symptoms of eye discomfort, itchy/burning/dry eyes, and foreign body sensation during lens wear at night: Only one subject reported itchy/burning/dry eyes for three or more days (times) per week,

Table 4

Demographics and baseline data of the subjects (Median (range) or Mean ± SD).

	Single vision spectacle group n = 20	Orthokeratology group n = 20	<i>P</i>
Age, y	10 (8 – 12)	10 (9 – 12)	0.91
Male/Female	10/10	10/10	1.00
Myopia for right eye, D	−2.49 ± 1.06	−3.16 ± 1.18	0.06
Myopia for left eye, D	−2.53 ± 0.96	−3.11 ± 1.32	0.12
Astigmatism for right eye, D	−0.75 (−1.50 – 0.00)	−0.50 (−1.50 – 0.00)	0.53
Astigmatism for left eye, D	−0.75 (−1.25 – 0.00)	−0.63 (−1.50 – 0.00)	0.55
BCVA, logMAR	0.00 (−0.10 – 0.00)	0.00 (−0.20 – 0.00)	0.26
Duration of lens wear, months	13 (10 – 18)	13 (12 – 18)	0.74

P – Probability value for differences among the two groups of subjects (Unpaired *t*-test was used for myopia, Chi-Square test for gender comparison, Mann-Whitney test for the rest).

Table 5PREP scores of the two groups of subjects. (Median (range) or Mean \pm SD).

Items	Single vision spectacle group n = 20	Orthokeratology group n = 20	P
Overall VA	75 (42–100)	96 (75–100)	<0.001
Near VA	100 (75–100)	100 (88–100)	0.10
Far VA	75 (13–100)	88 (75–100)	0.03
Symptoms	78 (38–100)	72 (38–100)	0.37
Appearance	58 (17–92)	96 (67–100)	<0.001
Satisfaction	38 (0–100)	100(75–100)	<0.001
Activities	38 (0–100)	100 (100–100)	<0.001
Academics	50(25–75)	50 (25–75)	0.58
Handling	81 (50–100)	69 (44–100)	0.04
Peer perception	63 (25–100)	67 (50–100)	0.02
Overall	68 \pm 10	81 \pm 6	<0.001*

Bold values indicate statistical significance at 0.05.

P – Probability value for score difference between two groups using the Mann–Whitney test, except for the last item* where unpaired *t*-test was used.**Table 6**Number (Percentage) of subjects with scores > 3 (disagree – strongly disagree) or \leq 3 (neutral – strongly agree) for symptoms during orthokeratology lens wear at night and number of subjects reporting the different frequencies of the symptoms.

Symptom	Score > 3	Score \leq 3	1 time per week	2 times per week	\geq 3 times per week
Experienced difficulty in falling asleep	20 (100 %)	0 (0%)	0	0	0
Experienced ocular discomfort	13 (65 %)	7 (35 %)	4	3	0
Experienced itchy/burning/dry eyes	12 (60 %)	8 (40 %)	1	6	1
Experienced foreign body sensation	14 (70 %)	6 (30 %)	2	4	0

while the remainder reported 1–2 times per week.

4. Discussion

Significantly higher overall vision and far vision scores were found in the ortho-k group compared to the SVS group. The results were similar to previous studies, which used the PREP questionnaire to compare vision related quality of life between children wearing contact lenses and those wearing SVS [8,13,15].

The scoring method of PREP questionnaire used in current study followed the instructions for PREP [8,10,13,15], changing the 5-point scale to 100-point scale. Although such scale conversion may not be ideal as there was no certainty that the intervals were equal, it was necessary to allow comparison with the results of previous surveys that used PREP questionnaire. In addition, it should be noted that even without conversion, data analysis produced the same statistical outcomes, indicating that the scale conversion did not affect the results.

Although there was no significant difference in BCVA in baseline characteristics between two groups, BCVA only reflected central vision. It has been reported that ortho-k provides not only good central vision, but also better correction of peripheral vision than spectacles [21–23], which may explain the higher overall scores for overall vision and distant vision in the ortho-k group.

There was no significant difference in near vision scores between two groups, which was similar to the findings of Walline's study where the scores of soft contact lens wearers were compared with SVS wearers [8]. However, Santodomingo-Rubido and co-workers [15] reported worse near vision for their ortho-k subjects compared to their SVS subjects, and they attributed that to slight over-correction and diurnal regression in

their ortho-k subjects.

With regard to appearance, satisfaction, activities, and peer perception, the higher scores in the ortho-k group were in agreement with the previous study [15]. Ortho-k lenses are worn only at night and children can enjoy clear vision in the daytime and, if full or close to full reduction of the refractive error is achieved, without the need for spectacles or contact lenses. This is particularly convenient when participating in activities, such as dancing and playing sports. Ortho-k may also be cosmetically desirable, allowing children spectacle-free vision. Previous studies have reported higher preference for soft contact lenses compared to spectacles, as the latter may be considered less attractive [11,24,25]. In Zhao et al.'s study [19], the quality of life scores were significantly higher after commencing ortho-k lens wear and the main reason why their subjects chose ortho-k was convenience in athletic activities.

Significantly lower scores with respect to handling of optical corrections were noted in the ortho-k group compared to the SVS group, which differed from some previous studies [13,15]. Pineda et al. [13] reported that the rating of handling was better in the MiSight contact lens group than that in SVS group, whilst similar ratings were reported for the ortho-k and SVS groups by Santodomingo-Rubido et al. [15]. Although studies have shown that children are capable of successfully handling both soft disposable and rigid gas permeable contact lenses [26,27], undeniably, compared to spectacles, handling of ortho-k lenses and accessories requires more effort and time, even with parental help. Also, some previous studies [13,26,28], investigated daily disposable soft contact lenses use, which does not require time and effort on care procedure. Ortho-k lenses are worn overnight and by children, which increases risk of adverse events when compared other daywear contact lenses [18]. To increase safety in ortho-k treatment, wearers are usually repeatedly reminded to strictly follow care procedures and maintain good compliance [29]. Therefore, in comparison, spectacles are much easier to handle, resulting in higher scores in handling compared to the ortho-k group.

With regard to scores for symptoms in the daytime and academic work, no significant differences were found between the two groups. Two previous studies [14,30] conducted on adults reported that subjects with ortho-k reported far fewer symptoms in daytime, such as itching, burning and dryness, compared to those wearing soft contact lenses, although glare was more noticeable in ortho-k wearers. In a study investigating the performance of ortho-k with different compression factors in adults and identifying the factors affecting success, glare was the main complaint of adult ortho-k wearers [31]. Light distortion, such as haloes, occurring in the early stage of the treatment was reported by almost half of the adult ortho-k subjects [32]. For most subjects, the problem abated after several weeks into the treatment. It was postulated that the time required to adapt to lens wear might be related to subject's age and that it takes longer for older subjects to adapt [32]. Interestingly, from clinical experience, children tend to be less sensitive to glare than adults, even with similar lens centration. Although the exact mechanism is not clear, it may reflect age differences in neuroadaptation to the perception of glare or haloes. As the current study was conducted on children, it may explain why there was no significant difference of symptoms in the daytime between ortho-k and SVS groups.

Lipson [14] reported that 67.7 % subjects chose ortho-k over disposable soft contact lens for refractive correction after completion of the study. In a similar study [30], the same author observed that 71 % subjects preferred ortho-k to soft contact lens for refractive correction. Duong et al. [33] refitted symptomatic soft contact lens wearers into ortho-k and found that ortho-k provided patients with comparable vision to soft contact lens vision and allowed better comfort than with daytime soft contact lens wear.

No significant difference of scores in academic performance between the two groups were found in the current study, which was in contrast to an earlier report [15], in which it was assumed that the poorer scores in the SVS group were attributable to failure of children to actually wear

their spectacles during school and homework time [15]. However, all the subjects with spectacle correction in the current study wore their lenses in the daytime, only removing them before sleep according to the practitioner's advice. Both spectacles and ortho-k treatment provided satisfactory visual acuity for the daily academic studies, which may account for the similar academic scores in the two groups.

With regard to the four additional questions on symptoms for ortho-k wearers, the proportion of subjects with an average score lower than 3 for symptoms experienced during lens wear at night was low. All subjects disagreed that wearing ortho-k lenses would affect their ability to fall asleep. The frequencies of ocular discomfort, itchy/burning/dry eyes, and foreign body sensation during ortho-k wear at night were reported to occur about 1–2 times per week, except for one subject who reported three or more times. Itchy eyes and foreign body sensation were also the most common symptoms of discomfort reported after commencing ortho-k lens wear by Zhao et al. [19]. Since ortho-k lenses are rigid, initially experiencing some discomfort is not unexpected. The benefits of ortho-k lens wear, such as better appearance and freedom from the need for vision correction in daytime may compensate most ortho-k wearers for the occasional discomfort, leading to overall satisfaction with ortho-k vision correction.

One limitation of this study is that subjects were all recruited from the same hospital in a major city, which may limit the generalization of the findings. A larger scale study including different regions of China is warranted to compare and contrast effects of ortho-k on VRQoL in children across the country. In addition, the current study was a retrospective cohort study and whilst a prospective study design would be preferable to minimize recall bias, all subjects had worn their optical corrections for 12–18 months and, as PREP scores stabilized after three months of contact lens wear [8,15], the results should reflect the true vision-related quality of life for children. PREP-OK was a minimally modified version of the validated PREP questionnaire in current study. To ensure validity, the Cronbach's Alpha was determined for PREP-OK and exceeded 0.7, indicating good reliability. As such, PREP-OK could be utilized for QoL assessment in future studies with young ortho-k wearers.

In summary, this study shows that a significantly better VRQoL in Chinese children wearing ortho-k, compared with SVS. Although ortho-k may be associated with some infrequent discomfort with lens wear at night, the benefits from ortho-k may compensate for the symptoms, leading to higher satisfaction with ortho-k treatment.

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Declaration of Competing Interest

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References

- [1] Cho P, Cheung SW, Edwards M. The longitudinal orthokeratology research in children (LORIC) in Hong Kong: a pilot study on refractive changes and myopic control. *Curr Eye Res* 2005;30:71–80. <https://doi.org/10.1080/027136805090907256>.
- [2] Cho P, Cheung SW. Retardation of myopia in orthokeratology (ROMIO) study: a 2-year randomized clinical trial. *Invest Ophthalmol Vis Sci* 2012;53:7077–85. <https://doi.org/10.1167/iov.12-10565>.
- [3] Santodomingo-Rubido J, Villa-Collar C, Gilmartin B, Gutiérrez-Ortega R. Myopia control with orthokeratology contact lenses in Spain: refractive and biometric changes. *Invest Ophthalmol Vis Sci* 2012;53:5060–5. <https://doi.org/10.1167/iov.11-8005>.
- [4] Hiraoka T, Kakita T, Okamoto F, Takahashi H, Oshika T. Long-term effect of overnight orthokeratology on axial length elongation in childhood myopia: a 5-year follow-up study. *Invest Ophthalmol Vis Sci* 2012;53:3913–9. <https://doi.org/10.1167/iov.11-8453>.
- [5] Chen C, Cheung SW, Cho P. Myopia control using toric orthokeratology (TO-SEE study). *Invest Ophthalmol Vis Sci* 2013;54:6510–7. <https://doi.org/10.1167/iov.13-12527>.
- [6] Charm J, Cho P. High myopia-partial reduction ortho-k: a 2-year randomized study. *Optom Vis Sci* 2013;90:530–9. <https://doi.org/10.1097/OPX.0b013e318293657d>.
- [7] Huang J, Wen D, Wang Q, McAlinden C, Flitcroft I, Chen H, et al. Efficacy comparison of 16 interventions for myopia control in children: a network meta-analysis. *Ophthalmology* 2016;123:697–708. <https://doi.org/10.1016/j.ophtha.2015.11.010>.
- [8] Walline JJ, Gaume A, Jones LA, Rah MJ, Manny RE, Berntsen DA, et al. Benefits of contact lens wear for children and teens. *Eye Contact Lens* 2007;33:317–21. <https://doi.org/10.1097/ICL.0b013e31804f80fb>.
- [9] Walline JJ, Bailey MD, Zadnik K. Vision-specific quality of life and modes of refractive error correction. *Optom Vis Sci* 2000;77:648–52. <https://doi.org/10.1097/00006324-200012000-00011>.
- [10] Rah MJ, Walline JJ, Jones-Jordan LA, Sinnott LT, Jackson JM, Manny RE, et al. Vision specific quality of life of pediatric contact lens wearers. *Optom Vis Sci* 2010;87:560–6. <https://doi.org/10.1097/OPX.0b013e3181e6a1c8>.
- [11] Walline JJ, Jones LA, Sinnott L, Chitkara M, Coffey B, Jackson JM, et al. Randomized trial of the effect of contact lens wear on self-perception in children. *Optom Vis Sci* 2009;86:222–32. <https://doi.org/10.1097/OPX.0b013e3181971985>.
- [12] Walline JJ, Jones LA, Chitkara M, Coffey B, Jackson JM, Manny RE, et al. The adolescent and child health initiative to encourage vision empowerment (ACHIEVE) study design and baseline data. *Optom Vis Sci* 2006;83:37–45. <https://doi.org/10.1097/01.opx.0000195566.94572.eb>.
- [13] Pomedá AR, Pérez-Sánchez B, Cañadas Suárez MDP, Prieto Garrido FL, Gutiérrez-Ortega R, Villa-Collar C. MiSight Assessment Study Spain: a comparison of vision-related quality-of-life measures between MiSight contact lenses and single-vision spectacles. *Eye Contact Lens* 2018;44:S99–104. <https://doi.org/10.1097/ICL.0000000000000413>.
- [14] Lipson MJ, Sugar A, Musch DC. Overnight corneal reshaping versus soft disposable contact lenses: vision-related quality-of-life differences from a randomized clinical trial. *Optom Vis Sci* 2005;82:886–91. <https://doi.org/10.1097/01.opx.0000180818.40127.dc>.
- [15] Santodomingo-Rubido J, Villa-Collar C, Gilmartin B, Gutiérrez-Ortega R. Myopia control with orthokeratology contact lenses in Spain: a comparison of vision-related quality-of-life measures between orthokeratology contact lenses and single-vision spectacles. *Eye Contact Lens* 2013;39:153–7. <https://doi.org/10.1097/ICL.0b013e31827a0241>.
- [16] Wang Z, Xie P. The hyper-Dk rigid gas permeable contact lens for the correction of high and special ametropia. *Chinese Journal of Optometry & Ophthalmology* 2008;10:212–4.
- [17] Cheung SW, Lam C, Cho P. Parents' knowledge and perspective of optical methods for myopia control in children. *Optom Vis Sci* 2014;91:634–41. <https://doi.org/10.1097/OPX.0000000000000259>.
- [18] Liu YM, Xie P. The safety of orthokeratology—a systematic review. *Eye Contact Lens* 2016;42:35–42. <https://doi.org/10.1097/ICL.0000000000000219>.
- [19] Zhao F, Zhao G, Zhao Z. Investigation of the effect of orthokeratology lenses on quality of life and behaviors of children. *Eye Contact Lens* 2018;44:335–8. <https://doi.org/10.1097/ICL.0000000000000529>.
- [20] Streiner DL. Best (but oft-forgotten) practices: the multiple problems of multiplicity - whether and how to correct for many statistical tests. *Am J Clin Nutr* 2015;102:721–8. <https://doi.org/10.3945/ajcn.115.113548>.
- [21] Queirós A, González-Méijome JM, Jorge J, Villa-Collar C, Gutiérrez AR. Peripheral refraction in myopic patients after orthokeratology. *Optom Vis Sci* 2010;87:323–9. <https://doi.org/10.1097/OPX.0b013e3181d9517f>.
- [22] Lin Z, Martinez A, Chen X, Li L, Sankaridurg P, Holden BA, et al. Peripheral defocus with single-vision spectacle lenses in myopic children. *Optom Vis Sci* 2010;87:4–9. <https://doi.org/10.1097/OPX.0b013e3181c078f1>.
- [23] Walline JJ, Bailey MD, Zadnik K. Vision-specific quality of life and modes of refractive error correction. *Optom Vis Sci* 2000;77:648–52. <https://doi.org/10.1097/00006324-200012000-00011>.
- [24] Terry RL. Eyeglasses and gender stereotypes. *Optom Vis Sci* 1989;66:694–7. <https://doi.org/10.1097/00006324-198910000-00006>.
- [25] Terry RL, Stockton LA. Eyeglasses and children's schemata. *J Soc Psychol* 1993;133:425–38. <https://doi.org/10.1080/00224545.1993.9712166>.
- [26] Walline JJ, Long S, Zadnik K. Daily disposable contact lens wear in myopic children. *Optom Vis Sci* 2004;81:255–9. <https://doi.org/10.1097/00006324-200404000-00011>.
- [27] Katz J, Schein OD, Levy B, Cruiscullo T, Saw SM, Rajan U, et al. A randomized trial of rigid gas permeable contact lenses to reduce progression of children's myopia. *Am J Ophthalmol* 2003;136:82–90. [https://doi.org/10.1016/s0002-9394\(03\)00106-5](https://doi.org/10.1016/s0002-9394(03)00106-5).
- [28] Rah MJ, Walline JJ, Jones-Jordan LA, Sinnott LT, Jackson JM, Manny RE, et al. Vision specific quality of life of pediatric contact lens wearers. *Optom Vis Sci* 2010;87:560–6. <https://doi.org/10.1097/OPX.0b013e3181e6a1c8>.

- [29] Cho P, Cheung SW, Mountford J, White P. Good clinical practice in orthokeratology. *Cont Lens Anterior Eye* 2008;31:17–28. <https://doi.org/10.1016/j.clae.2007.07.003>.
- [30] Lipson MJ, Sugar A, Musch DC. Overnight corneal reshaping versus soft daily wear: a visual quality of life study (interim results). *Eye Contact Lens* 2004;30:214–7. <https://doi.org/10.1097/01.icl.0000140236.23820.97>. discussion 218.
- [31] Ren Q, Yang B, Liu L, Cho P. Orthokeratology in adults and factors affecting success: study design and preliminary results. *Cont Lens Anterior Eye* 2020;(May 1). <https://doi.org/10.1016/j.clae.2020.03.016>. S1367-0484(20)30058-8.
- [32] Santolaria E, Cerviño A, Queirós A, Brautaset R, González-Méijome JM. Subjective satisfaction in long-term orthokeratology patients. *Eye Contact Lens* 2013;39:388–93. <https://doi.org/10.1097/ICL.0b013e3182a27777>.
- [33] Duong K, McGwin Jr G, Franklin QX, Cox J, Pucker AD. Treating uncomfortable contact lens wear with orthokeratology. *Eye Contact Lens* 2020;(February 24). <https://doi.org/10.1097/ICL.0000000000000690> [Epub ahead of print].