Systematic Review and Meta-Analysis

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Effect of the combined application of orthokeratology and single-vision spectacles on slowing the progression of high myopia

A systematic review and meta-analysis

Congling Zhao, MD[a], Chunyan Cai, MD[a], Hongbin Dai, MM[a], Jun Zhang, MM[a,*]

Abstract

Purpose: The purpose of the study was to conduct a meta-analysis about the effect of the combined application of orthokeratology and single-vision spectacles on slowing the progression of high myopia.

Methods: The literature was searched in PubMed, EMBASE, the Cochrane Library, Wang Fang Data, CNKI and sinoMed. The Cochrane Handbook was used to evaluate the quality of the included randomized clinical trials, and the Newcastle-Ottawa Scale was used to evaluate the included case–control or cohort studies. The results were analyzed by Revman 5.3.

Results: Five studies (2 randomized clinical trials, 2 case–controls, and 1 cohort study) with a total of 360 patients were included in this meta-analysis. The follow-up time was at least 1 year. Combined application of orthokeratology and single-vision spectacles were used in the experimental group. The control group used single-vision spectacles only. The pooled estimates indicated that the standardized mean difference between the 2 groups was –1.46 mm (95% confidence interval: –1.88 to –1.05; $P < .05$) for axial length elongation and –1.85D (95% confidence interval: –2.40 to –1.31; $P < .05$) for change in spherical equivalent refraction. No serious adverse events were reported in all studies.

Conclusion: The combined application of orthokeratology and single-vision spectacles is more effective than single-vision spectacles only on slowing the progression of high myopia.

Abbreviations: AL = axial length, CI = confidence interval, RCTs = randomized controlled trials, SER = spherical equivalent refraction, SMD = standardized mean difference.

Keywords: high myopia, meta-analysis, myopia progression, orthokeratology

1. Introduction

Myopia, which is the main reason for preventable blindness, is widespread around the world at an alarming rate, especially in Asian countries.[1] The age of onset of myopia is getting younger, and the prevalence of myopia and high myopia is increasing dramatically.[2] Among the adult population (≥40 years) in Australia and the United States, the prevalence of high myopia is 2% to 4%. Among freshmen in Taiwan University, the prevalence of high myopia (>6.00D) is the highest, up to 38.4%.[3]

High myopia which is >6.00D was often accompanied by sight-threatening complications. Myopic retinopathy, maculopathy, choroidal neovascularization, retinal detachment, posterior staphyloma, optic disc abnormalities, glaucoma, and cataract were reported for the complications of high myopia. These complications above were related to the increased axial length (AL).[4] Therefore, delaying AL elongation can effectively prevent the occurrence of myopia complications.

Myopia progression is calculated as spherical equivalent refraction (SER) changes from baseline.[5] AL elongation is closely related to the progression of myopia, and it is an important indication of the progression of myopia.[6] Therefore, controlling AL and SER can slow the myopia progression.[7–9] Many studies had been carried out to reduce the prevalence of myopia and prevent its complications. Orthokeratology was 1 of the most effective ways to delay the progression of myopia by creating peripheral retinal myopia defocus.[10] Orthokeratology was approved by the US Food and Drug Administration in 2002 to correct myopia, but the corrections was only up to 6.00D.[11] Therefore, overnight orthokeratology (ortho-k) could only partially reduce the refractive errors; spectacles was needed in the daytime for high myopia. There was no large-scale multicenter study to explore this combined

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The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request. CZ should be contacted if someone wants to request the data.

All analyses were based on previous published studies, thus no ethical approval and patient consent are required.

[a] Aier Eye Hospital of Wuhan University, Wuhan, China.

**Correspondence: Jun Zhang, Aier Eye Hospital of Wuhan University, Wuhan, Hubei Province, China (e-mail: fll520191@163.com).*

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application. This meta-analysis summarized the existing literature and discussed the role of this combination on slowing the progression of high myopia.

2. Materials and Methods

This systematic review and meta-analysis was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines. No protocol was used for this meta-analysis. The ethical approval was not necessary and waived.

2.1. Information source and search strategy

PubMed, EMBASE, and the Cochrane Library were searched using the term "orthokeratology and high myopia." By mesh term searching in PubMed, both "orthokeratology" and "high myopia" were no free words. Wang Fang Data, CNKI, and sinoMed were also searched in Chinese.

2.2. Inclusion criteria

The following inclusion criteria were used to identify eligible studies for this meta-analysis:

1. The studies were clinical randomized controlled trials (RCTs), case–control, or cohort studies.
2. Both orthokeratology and single-vision spectacles were used in the experimental group. The control group used single-vision spectacles only.
3. Participants in the study were <18 years old and had myopia.
4. The study reported at least the AL change or the annual rate of myopia progression.

CZ and CC independently reviewed the title, abstract, and full text, using the above standards to identify eligible studies. Disagreements regarding eligibility were solved through discussion with JZ.

2.3. Data collection and quality assessment

CZ and CC independently extracted data from the included studies using the preestablished data extraction tables, which included basic information of the study and the patient and assessed the quality of the studies independently.

The risk for bias of RCTs was assessed according to the Cochrane Handbook: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessments, incomplete outcome data, selective reporting, and other biases. The Newcastle–Ottawa Scale, which included patient selection, comparability, and Outcome/Exposure assessments, was used to assess the risk for bias of case–control or cohort studies. A study can be awarded a maximum of 1 star for each numbered item within the Selection and Outcome/Exposure categories. A maximum of 2 stars can be given for Comparability. A study with Newcastle-Ottawa Scale score >6 stars was considered as a high-quality study.

2.4. Statistical analysis

Review Manager software version 5.3 was used for this meta-analysis. The statistical heterogeneity was tested by the

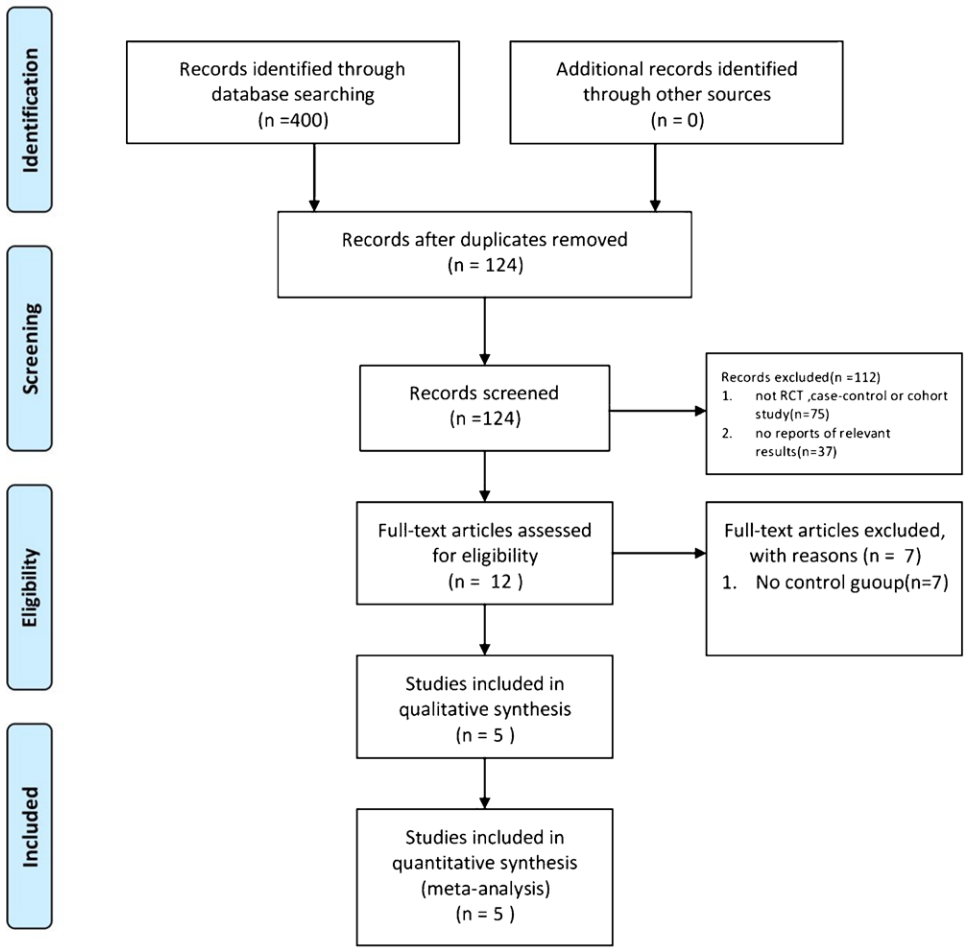

Figure 1. PRISMA flow diagram of the literature search process. PRISMA = Preferred Reporting Items for Systematic Reviews.

Table 1

Basic characteristics of studies included in this meta-analysis.

Study	Region	Design	Age (yr)	No. patients (OK/control)	Instrument	Refraction error (D)	Follow-up (yr)	The initial target of all lenses	The baseline SER
Charm et al[12]	China	RCT	8–11	12/16	Zeiss IOLMaster	SER: at least −5.75 Myopia: ≥−5.00	2	4.00	6.38 ± 1.85
Lyu et al[13]	China	Case–control	13.760 ± 2..152	60/59	Zeiss IOLMaster	SER: −6.00 to −10.00 Astigmatism: <1.50	1	6.00	−6.851 ± 0.913
Lyu et al[14]	China	RCT	8–15	30/31	Zeiss IOLMaster	SER: −6.00 to −8.75 Astigmatism: <1.50	1	4.00	−6.763 ± 0.741
Yi et al[15]	China	Case–control	10–14	23/30	A-scan	SER: −6.00 to −8.00 Astigmatism: <1.50	2	4.00	−6.99 ± 0.58
Zhu et al[16]	China	Cohort	8–15	57/42	Zeiss IOLMaster	SER: −6.00 to −9.00 Astigmatism: ≤1.50	1	6.00	−7.61 ± 0.67

RCT = randomized controlled trials, SER = spherical equivalent refraction.

Cochrane I^2 test. A fixed-effect model was used when I^2 was <50%. If I^2 was >50%, a random effects model was applied. The main outcomes included AL and SER change reported as the mean ± standard deviation with the 95% confidence interval (CI). A P value of <.05 was considered statistically significant. A sensitivity analysis was performed by excluding the included studies one by one. Owing to the limited number (<10) of included studies, publication bias was not assessed.

3. Results

3.1. Searching results and study characteristics

After searching the database, a total of 400 studies were obtained (PubMed: 92, Embase: 50, Cochrane Library: 31, Wang Fang Data: 94, CNKI: 100, sinoMed: 33). Based on the inclusion criteria, by screening the title, abstract, and full text, a total of 5 studies (two randomized RCTs, 2 case–controls, and 1 cohort study) were included in this meta-analysis. The Preferred Reporting Items for Systematic Reviews Flow Diagram is shown in Figure 1. A total of 360 patients (182 in the experimental group and 178 in the control group) were included in this meta-analysis, and the follow-up period was at least 1 year. The basic characteristics of the included studies are shown in Table 1. The quality of the included studies was generally high (Fig. 2, Tables 2 and 3).

3.2. Change in AL

According to the heterogeneity results (P = .02, I^2 = 65%), a random effect model was used. As shown in Figure 3, the AL increased in both groups and showed a significant difference

Figure 2. The risk for bias of RCTs included in the meta-analysis according to the Cochrane Handbook. RCT = randomized controlled trial.

Table 2

Quality assessment of cohort studies included in the meta-analysis using Newcastle–Ottawa Quality Assessment Scale.

	Selection					Outcome		
Study	Exposed cohort representative	Nonexposed cohort selection	Exposure ascertainment	Outcome not present at start	Comparability	assessment	Follow-up length	Follow-up adequacy
Zhu et al[16]	*	*	*	*	**	*	*	*

The star (*) indicates score. A study can be awarded a maximum of 1 star for each numbered item within the Selection and Outcome categories. A maximum of 2 stars can be given for Comparability.

Table 3

Quality assessment of case–control studies included in the meta-analysis using Newcastle–Ottawa Quality Assessment Scale.

	Selection					Exposure		
Study	Adequate definition of cases	Representativeness of the cases	Selection of controls	Definition of controls	Comparability control for important factor	Ascertainment of exposure	Same method of ascertainment for cases and controls	Nonresponse rate
Lyu et al[13]	*	*	*	*	**	*	*	–
Yi et al[15]	*	*	*	*	**	*	*	–

The star (*) indicates score. A study can be awarded a maximum of 1 star for each numbered item within the Selection and Exposure categories. A maximum of 2 stars can be given for Comparability control for important factor.

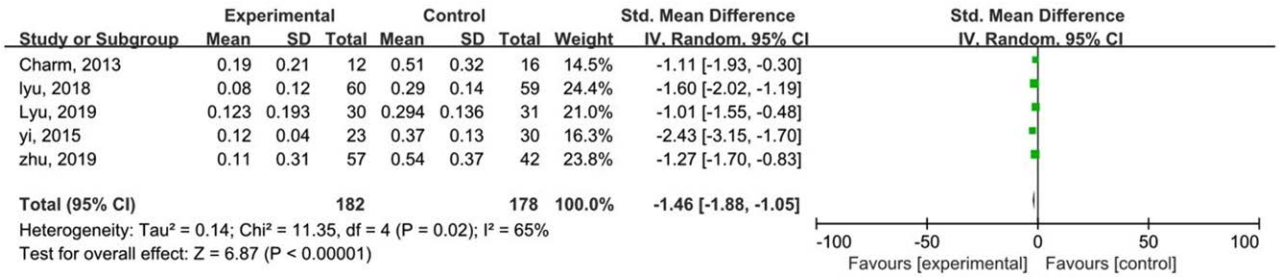

Figure 3. Forest plots of the effect on axial length elongation.

between the 2 groups. The standardized mean difference (SMD) with a 95% CI of the less change in AL was –1.46 mm (95% CI: –1.88 to –1.05; $P < .05$). Exclusion of any single study did not alter the overall effect. Therefore, the result was robust.

3.3. Change in SER

Only 3 studies reported changes in refractive error, with a heterogeneity of 70%, so a random effects model was used. As shown in Figure 4, there was a significant difference in the change for SER. The SMD with a 95% CI of the change in SER was –1.85 D (95% CI: –2.40 to –1.31; $P < .05$).

3.4. Ocular health

Charm and Cho[12] found that after wearing orthokeratology, the incidence of corneal staining was higher than that of the control group, but these staining were not significant. And Lyu et al[13] reported that there was no significant difference in corneal endothelial cell density between the 2 groups.

4. Discussion

High myopia and ocular complications seriously affected the vision and imposed a huge burden on society. Therefore, slowing the progression of high myopia was urgent. Orthokeratology had achieved good outcomes in slowing the progression of myopia from low to moderate myopia,[14] but there were few studies on its application in high myopia.

Our meta-analysis suggested that the SMD between the 2 groups was –1.46 mm (95% CI: –1.88 to –1.05; $P < .05$) for AL elongation and –1.85D (95% CI: –2.40 to –1.31; $P < .05$) for change in SER. Orthokeratology can safely and effectively delay the progression of myopia in patients with high myopia with fewer complications.

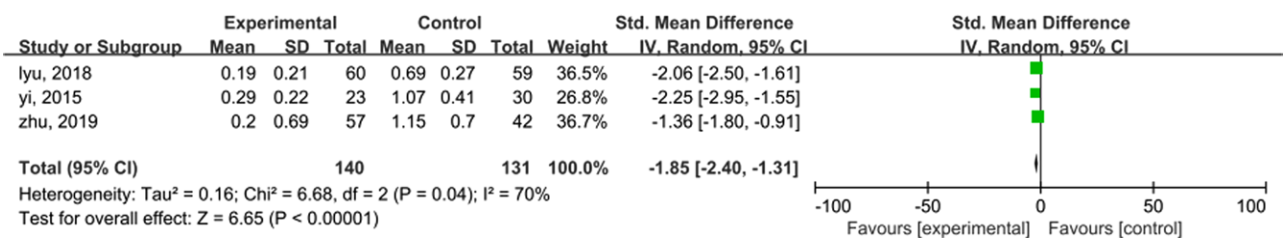

Figure 4. Forest plots of the effect on SER. SER = spherical equivalent refraction.

The effect and safety of orthokeratology in delaying the progression of myopia had been widely studied,[15,16] but it was mainly concentrated in low and moderate myopia, and its effects in high myopia have not been well studied. This meta-analysis is the first about the combined application of orthokeratology and single-vision spectacles. The results showed that the combined application of orthokeratology and single-vision spectacles is more effective than single-vision spectacles only on slowing the progression of high myopia.

This meta-analysis had some limitations. First, only the diopters and changes in the length of the eye axis were evaluated. Other indicators related to the progression of myopia, such as the depth of the vitreous cavity and the thickness of the choroid, were not analyzed. Second, the relatively small sample size (only 5 studies including 360 patients) were involved in this analysis, which prevented us from obtaining adequate evidence. Third, this meta-analysis only included 2 RCTs, and the longest follow-up time of the included studies was 2 years, so further RCT about longer-term effects were still needed.

5. Conclusion

The combined application of orthokeratology and single-vision spectacles is more effective than single-vision spectacles only on slowing the progression of high myopia.

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Author contributions

CZ designed this study. CZ and CC collected and double checked the data. CZ wrote the paper. HD and JZ provided critical revision to the article. All authors participated in revision and approved the final version for submission.
Conceptualization: Congling Zhao.
Data curation: Chunyan Cai, Congling Zhao, Hongbin Dai.
Investigation: Chunyan Cai.
Methodology: Congling Zhao.
Software: Chunyan Cai.
Supervision: Jun Zhang.
Writing – original draft: Congling Zhao.
Writing – review & editing: Hongbin Dai, Jun Zhang.

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