One-year effect of wearing orthokeratology lenses on the visual quality of juvenile myopia: a retrospective study

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Objective . To study the one-year effect of wearing orthokeratology (OK) lenses on the visual quality of juvenile myopia. **Methods.** The right eyes of 36 juvenile myopias were retrospectively studied in this work. Q-value, e-value, corneal curvature, strehl ratio (SR), modulation transfer function (MTF) and wavefront aberration (WA) were compared before and at 1, 3 and 12 months after wearing OK lenses. The SR, MTF and WA of cornea, internal optic and ocular were analyzed separately. The spherical and cylinder diopter, vision acuity, compensating factor (CF) and compensative rate (CF%) were compared before and at 12 months after wearing OK lenses. **Results.** (1) The vision of LogMAR increased and the corneal curvature decreased significantly after wearing OK lenses. There was no significant difference for the e-value before and after wearing OK lenses. The Q-value increased at 1 month but decreased at 3 and 12 months remarkably. (2) The ocular and internal optic SR and MTF increased significantly at 1 month and then remained stable. The MTF in different spacial frequencies increased after wearing OK lenses. There was no significant difference for the corneal SR before and after wearing OK lenses, and the corneal MTF decreased significantly after wearing OK lenses. (3) For the ocular, the total higher order aberration (HOA), spherical, coma and trefoil aberrations increased, and the total aberration, total lower order aberration (LOA) and defocus aberration decreased obviously except astigmatism. The corneal aberrations increased significantly after wearing OK lenses except astigmatism. For the internal optic, the total aberration, total LOA and defocus aberration decreased, and the total HOA, coma and trefoil aberration increased significantly except the astigmatism and spherical aberrations. (4) The CF and CF% of total aberration, total LOA, total HOA and coma aberrations increased, and those of astigmatism and spherical decreased at 12 months. **Conclusions.** Orthokeratology is effective in correcting the refractive error and improving the vision quality of juvenile myopia over the one-year follow-up period.

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on the Visual Quality of Juvenile Myopia: A

Retrospective Study

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Abstract

16   **Objective.** To study the one-year effect of wearing orthokeratology (OK) lenses on the visual

17   quality of juvenile myopia.

18   **Methods.** The right eyes of 36 juvenile myopias were retrospectively studied in this work. Q-

19   value, e-value, corneal curvature, strehl ratio (SR), modulation transfer function (MTF) and

20   wavefront aberration (WA) were compared before and at 1, 3 and 12 months after wearing OK

21   lenses. The SR, MTF and WA of cornea, internal optic and ocular were analyzed separately. The

22   spherical and cylinder diopter, vision acuity, compensating factor (CF) and compensative rate

23   (CF%) were compared before and at 12 months after wearing OK lenses.

24   **Results.** (1) The vision of LogMAR increased and the corneal curvature decreased

25   significantly after wearing OK lenses. There was no significant difference for the e-value before

26   and after wearing OK lenses. The Q-value increased at 1 month but decreased at 3 and 12

27   months remarkably. (2) The ocular and internal optic SR and MTF increased significantly at 1

28   month and then remained stable. The MTF in different spacial frequencies increased after

29   wearing OK lenses. There was no significant difference for the corneal SR before and after

30   wearing OK lenses, and the corneal MTF decreased significantly after wearing OK lenses. (3)

31   For the ocular, the total higher order aberration (HOA), spherical, coma and trefoil aberrations

32   increased, and the total aberration, total lower order aberration (LOA) and defocus aberration

33   decreased obviously except astigmatism. The corneal aberrations increased significantly after

34   wearing OK lenses except astigmatism. For the internal optic, the total aberration, total LOA and

35   defocus aberration decreased, and the total HOA, coma and trefoil aberration increased

36   significantly except the astigmatism and spherical aberrations. (4) The CF and CF% of total

37   aberration, total LOA, total HOA and coma aberrations increased, and those of astigmatism and

38   spherical decreased at 12 months.

39   **Conclusions.** Orthokeratology is effective in correcting the refractive error and improving the

40   vision quality of juvenile myopia over the one-year follow-up period.

41

42 1. Introduction

43   Orthokeratology (OK) is a non-invasive technology for refractive correction [1] and has been

44   widely applied to treat young myopic patients since the 1990s [2]. It has been generally

45   recognized that wearing this rigid contact lens at night can effectively reduce myopic degree [3,

46   4]. With a reverse geometry design, the rigid contact lens is able to flatten the center of the front

47   corneal surface by the pressure induced from the tear film and lids [5]. Meanwhile, the lens plays

48   an important role in controlling myopia progression with a mechanism of myopia shift [6, 7].

49   Moreover, the orthokeratic effect is reversible, and the cornea can recover to its original shape

50   after stopping wearing the lens for 1 to 6 months [8, 9].

51   In general, most OK users could obtain an effective refractive correction in the daytime.

52   However, there might be some side effects such as the night vision loss, ghosting, halos and

53   glares, particularly within the first month after wearing the lens [10]. Academically, there is still

54   no consensus that wearing OK lenses can help improve the visual quality [11, 12]. The

55   divergence might be associated with the amount of corrected refractive error, lens decentration

56   and different evaluation methods, etc [13, 14]. In this work, the iTrace aberrometer was used to

57 evaluate the visual quality objectively, which includes a few parameters that are with good
58 reproducibility, i.e. the asphericity of cornea (Q-value), eccentricity of cornea (e-value), strehl
59 ratio (SR), modulation transfer function (MTF) and wavefront aberration (WA) [15, 16].
60 Moreover, it is available to record the visual parameters respectively according to cornea,
61 internal optic and ocular, which makes it possible to quantificationally assess the
62 therapeutic effect of orthokeratology.

63   The main purpose of this work is to analyze the one-year effect of wearing OK lenses on the
64 visual quality of juvenile myopia, and explore the possible reasons for the limited alleviation of
65 vision quality. Corresponding statistical results could provide objective evidences to the
66 improvement of visual quality after wearing OK lenses, and make benefits to the fitting of OK
67 lens directly.

68

69 2. Patients and methods
70 2.1. Study subjects and Methods

71   36 myopic teenagers were enrolled, and the parameters of their right eyes were analyzed
72 retrospectively. The inclusion criteria was as follows: the age was 6~18 years old, and the
73 spherical diopter was $-1.00 \sim -7.00D$, and the cylinder diopter was $0D \sim -2.00D$, and the
74 treatment duration was more than one year with regular follow-up. The patients with any ocular
75 surface diseases, systemic diseases or a history of wearing any contact lens before the therapy
76 were excluded, and the teenagers who suffered any vision-threatening side events during the
77 therapy were also excluded. The enrolled patients wore the OK lens no fewer than 8 hours per
78 night and removed the lens before 7 am on the next day. The follow-up examinations were
79 performed between 8 and 10 am at each visit. The therapeutic process lasted for more than 1 year
80 from July 1st, 2015 to June 31st, 2017 in the vision care clinic of Xiangya Hospital, Central
81 South University, China. All the subjects underwent the examinations including slitlamp
82 microscope, manifest refraction and iTrace aberration examination before and at 1, 3 and 12
83 months after wearing OK lenses.

84   The spherical and cylinder diopter were measured by manifest refraction. The vision acuity
85 was obtained using the standard logarithmic visual acuity charts. The slitlamp microscopy was
86 used to detect the cornea. Q-value, e-value, corneal curvature, SR, MTF and WA were measured

87 by the iTrace aberration analyzer (TRACEY VFA2 iTrace) when the pupil size was 4 mm. All

88 the measurements were repeated 3 times for each eye. The compensating factor (CF) and

89 compensative rate (CF%) were obtained from the WAs. CF was calculated by 1 minus the

90 absolute ratio of ocular WA to corneal WA, and CF% referred to the ratio of positive CFs to all

91 CFs. The spherical and cylinder diopter, the visual acuity, the CF and CF% were compared

92 before and at 12 months, and the Q-value, e-value, corneal curvature, SR, MTF and WA were

93 analyzed before and at 1, 3 and 12 months. The subjects' personal information was anonymized

94 before the assessment.

95 This research project was reviewed and approved by the Ethic Committee of Xiangya

96 Hospital of Central South University (the IRB approval number is 201505044). The design and

97 methods of this research were in accordance with the requirements of regulations and procedures

98 regarding to the human subject protection laws such as GCP and ICH-GCP. This study adhered

99 to the tenets of the Declaration of Helsinki. Before wearing OK lenses, informed consents were

100 obtained from the subjects and their guardians who fully understood the protocol and potential

101 risks of the OK treatment. Permissions were also acquired to take the medical records of each

102 subject as experimental data for the research purpose.

103

104 2.2. Orthokeratology lens and lens fitting

105 The reverse-geometry OK lens (Japan alpha-ortho K) was applied in this work. The lens was

106 manufactured with Boston EM material, with the central thickness of 0.22 mm, refractive rate of

107 1.422 and gas permeability of $104\times10\text{-}11$ $(cm^2\times mlO_2)/(s\times mL\times mmHg)$. According to the

108 simulated keratometry, corneal curvature and desired refractive change, the subjects were fitted

109 with the lens using the lens-fitting software supplied by the manufacturers. The subjects wore the

110 selected lens for one-hour trial.

111

112 2.3. Statistical Analysis

113 The IBM SPSS23.0 statistical packages and Microsoft Excel were used for the data

114 management and analysis. The paired sample t-test was used to analyze the visual acuity, diopter

115 and CF when the data had a normal distribution, and the Wilcoxon signed rank test was
116 considered when the data distribution was abnormal. The one-way repeated measurement
117 analysis of variance was applied to analyze the differences of the corneal curvature, Q-value, e-
118 value, SR, MTF and WA before and at 1, 3 and 12 months after wearing OK lenses when the
119 data followed the law of normal distribution; if not, Friedman test was used. $p<0.05$ was
120 considered statistically significant for the visual acuity, diopter and CF, and the adjusted alpha i.e.
121 alpha/no. of test, was applied for the analysis with repeated measurement.

122

3. Results

3.1. Descriptive statistics of the subjects

125   The descriptive statistics of the myopic teenagers before and after wearing OK lenses were
126 summarized in Table 1. 19 females and 17 males aged of (10.8±2.2) years old were enrolled in
127 the study. It was informed that the spherical diopter decreased dramatically from (-3.403±1.580)
128 to (-0.410±0.330) at 12 months after wearing OK lenses; whereas the evolution of the cylinder
129 diopter was not obvious, relatively speaking. Moreover, the vision of LogMAR in the daytime
130 increased significantly at 12 months. Two subjects complained about ghosting in the initial
131 period of wearing OK lenses due to severe lens decentration, and this symptom gradually
132 vanished after refitting the lens. Three subjects had night vision impairment in the late period,
133 and a new pair of OK lenses was replaced after one year.

134

3.2. Comparison of corneal curvature, Q-value and e-value before and after wearing OK lenses

137   Since the improvement of vision acuity originates from the reshaping of cornea, the corneal
138 topography analysis is necessary for evaluating the effect of OK treatment. As shown in Table 2,
139 under the pressure induced by the OK lens, both horizontal and vertical corneal curvatures
140 reduced obviously after 1 month and kept stable subsequently. Meanwhile, Q-values increased at
141 1 month and gradually reduced at 3 and 12 months. For the e-value, no significant differences

142 were noticed at 1, 3 and 12 months when compared respectively with that before wearing OK
143 lenses.

144

3.3. Comparison of SR and MTF before and after wearing OK lenses

146   The objective evaluation of visual quality is necessary for the correction of refractive errors,
147 and SR and MTF quantitatively represent the variation of vision quality. As summarized in Table
148 3, both the ocular and internal optic SR and MTF increased significantly at 1 month and kept
149 stable at 3 and 12 months. It is noteworthy that the variation of corneal SR or MTF was different
150 from that of ocular and internal optic. No significant differences existed for corneal SR before
151 and after wearing OK lenses, and the corneal MTF decreased significantly after wearing OK
152 lenses.

153   The assessment of MTF at different spatial frequencies is important for estimating the
154 visual quality at different contrast levels. As illustrated in Figs. 1, 2 and 3, the evolution of
155 ocular, corneal and internal MTFs were addressed respectively. The ocular and internal optic
156 MTFs after wearing OK lenses were higher than those before wearing OK lenses at the same
157 spatial frequency. Moreover, the ocular, corneal and internal optic MTFs after wearing OK
158 lenses all decreased with the increase of the spatial frequency, which was similar with the
159 evolution tendency of MTFs before wearing OK lenses.

160

3.4. Comparison of wavefront aberrations before and after wearing OK lenses

3.4.1. Comparison of ocular aberrations

164   The statistical results of ocular aberrations were listed in Table 4. One can see that the total
165 higher order aberration (HOA), spherical, coma and trefoil aberrations increased obviously after
166 wearing OK lenses, except the trefoil aberration at 12 months which had no statistical difference
167 when compared with the baseline value. The total aberration, total lower order aberration (LOA)

168   and defocus aberrations decreased dramatically after wearing OK lenses. One exception was the

169   astigmatism aberration that had no obvious difference after wearing OK lenses.

170

3.4.2. Comparison of corneal aberrations

172   As summarized in Table 5, most of the corneal aberrations increased significantly after

173   wearing OK lenses. The exception was the post-treatment astigmatisms and the trefoil aberration

174   at 12 months, which revealed limited difference when compared with the baseline value.

175

3.4.3. Comparison of internal optic aberrations

177   As shown in Table 6 that the total aberration, total LOA and defocus aberrations of internal

178   optic decreased significantly, and the total HOA, coma and trefoil aberrations increased

179   obviously after wearing OK lenses except the trefoil aberration at 12 months. It's remarkable that

180   there were no significant differences for the astigmatism and spherical aberrations after wearing

181   OK lenses when compared with the baseline value.

182

3.4.4. Comparison of CF and CF% of aberrations

184   The CF of total aberration, total LOA, total HOA and coma aberrations increased

185   significantly at 12 months, and the corresponding CF% also increased after wearing OK lenses.

186   In contrast, there were no statistical significances for the CFs of defocus, astigmatism, spherical

187   and trefoil aberrations when compared with that before wearing OK lenses (as summarized in

188   Table 7).

189

4. Discussion

191   It is well known that orthokeratology is effective for the correction of refractive error [17, 18].

192   In this work, the effectiveness was further verified by the increase of the vision of LogMAR,

193   which relied on the reshaping of cornea that is represented by the variation of the corneal

194   curvature as well as the Q-value and e-value. Moreover, the corneal curvature, Q-value and e-
195   value remained unchanged for months after wearing OK lenses, which demonstrated the stable
196   and long-term correction effect of OK.

197   However, the improvement or decline of visual quality after wearing OK lenses still remains
198   in dispute. The eye is a complex and precise refractive system, and there are numbers of factors
199   that affect the visual quality, e.g. the diffraction, scattering and refraction of light. Defined by the
200   deviation between the actual and theoretical wavefront, wavefront aberration is known to reflect
201   the influence of optical factors on the visual imaging. In this work, the objective assessment
202   parameters of vision quality and wavefront aberrations were systematically measured and
203   analyzed respectively based on 3 sections of cornea, ocular and internal optic. The purpose of the
204   individual evaluation was to explore whether there were any differences and interactions
205   between different parts of the optical system. Similar researches have been seldom reported in
206   the published literature to the authors' knowledge.

207   Generally, the variations of ocular SR and MTF indicated that wearing OK lenses could help
208   ameliorate the visual quality of the juvenile myopias, and the visual quality in different spacial
209   frequencies was also improved. Individually, the decrease of corneal SR and MTF indicated the
210   negative effect of OK associated with corneal reshaping. The small irregularity of cornea after
211   reshaping can increase the light path of different parts of pupil, and thus produce higher corneal
212   aberrations. And the aberrations of the ocular and internal optic changed differently from the
213   corneal aberrations after wearing OK lenses. The various evolutions of wavefront aberrations
214   demonstrated that the compensating effect worked in this phenomenon, which has been noticed
215   in previous works [19-21]. The increased CF and CF% of some wavefront aberrations also
216   supported this view. The high corneal aberration can be compensated by the intraocular effect,
217   resulting in smaller aberration of the whole eye than that of the cornea. Moreover, the increase of
218   internal optic SR and MTF might cover the decrease of corneal SR and MTF, which finally
219   results in the increase of ocular SR and MTF and the improvement of visual quality.

220   However, the corneal astigmatism did not increase after wearing OK lenses. It was
221   speculated that the stable corneal astigmatism was related to the uniformity of the remodeling
222   force caused by the OK lens because the corneal curvature decreased synchronously along the
223   vertical axis and horizontal axis. The compensating effect of internal optic astigmatism on the
224   corneal astigmatism depended on the natural lens, and was related to the contraction of the

225 ciliary muscles in all directions. As the corneal astigmatism did not increase, there was no need
226 to activate the internal optic astigmatism to act as a neutralizing role. Therefore, both the ocular
227 and internal optic astigmatism did not increase. It also indicated that the compensation
228 mechanism was a kind of dynamic compensation. The other two noticeable features were that the
229 spherical aberration of internal optic remained unchanged after wearing OK lenses, and the
230 trefoil aberrations of the ocular, internal optic and cornea at 12 months all decreased to the
231 baseline value. It has been pointed out that the combination of trefoil, spherical aberration and
232 vertical coma aberration might help promote the growth of the eyeballs [22]. Moreover, the
233 vertical trefoil coupled with vertical coma could maximize the retinal image quality and reduce
234 the deleterious impact of trefoil in visual performance [23]. However, it is still not clear for the
235 comprehension of the connection between the distinctive changes of spherical and trefoil
236 aberration with the variation of eyeball and the visual quality, which deserves further exploration.
237

238 Furthermore, the compensation mechanisms are not clear so far [24, 25]. One possible
239 explanation might be the adaptive response of eye accommodation to corneal remolding, which
240 primarily relies on the contribution of lens. The OK lens can reduce the hypermetropic refraction
241 of the peripheral retina and improve the sensitivity and accuracy of accommodation that has tight
242 connection with the intraocular lens and ciliary muscle. With age, light, surgery or eye disease,
243 this compensation mechanism may attenuate or even be broken, which might help comprehend
244 the few inconformity of visual quality in some researches.

245 Last but not the least, it should be noted that there still remain some limitations in the present
246 work, e.g. some complications, including the lens decentration, dry eyes and corneal epithelium
247 damage, were not well addressed. A potential selection bias was also introduced by the strict
248 exclusion criteria about the adverse complications of wearing orthokeratology lenses. In addition,
249 one can also try to increase the sample size and follow-up time to further verify the statistical
250 results as observed in this work.

251

252 **5. Conclusion**
253 In conclusion, orthokeratology is effective for the correction of refractive error and
254 improvement of vision quality of juvenile myopia over the one-year follow-up period.

255

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330

Figure 1

The evolution of ocular MTF at different spatial frequencies before and at 1, 3, 12 months after wearing the OK lens. Error bar: standard devision.

Change of ocular MTF under different spatial frequencies

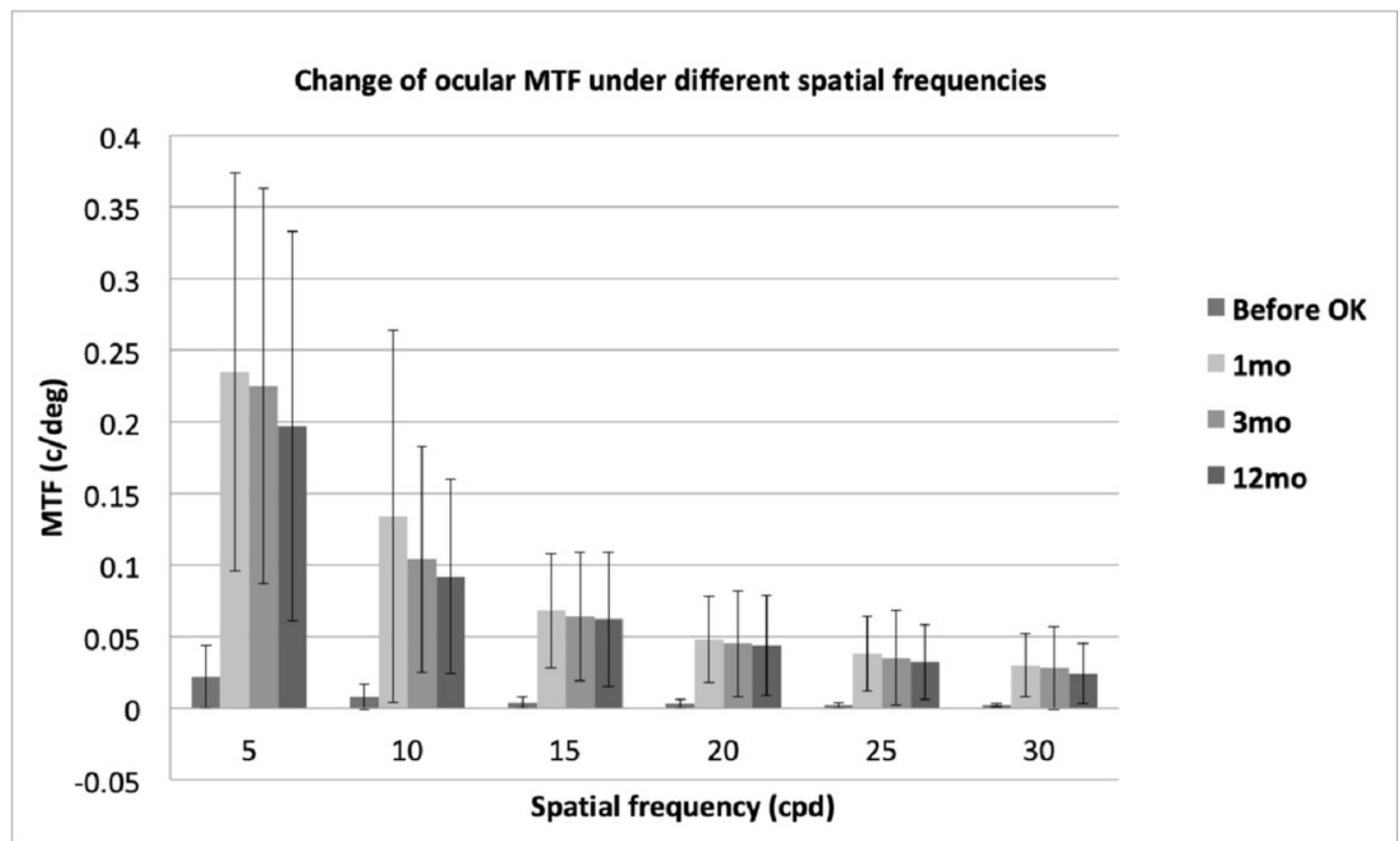



Figure 2

The evolution of corneal MTF at different spatial frequencies before and at 1, 3, 12 months after wearing OK lens. Error bar: standard devision.

Change of corneal MTF under different spatial frequencies

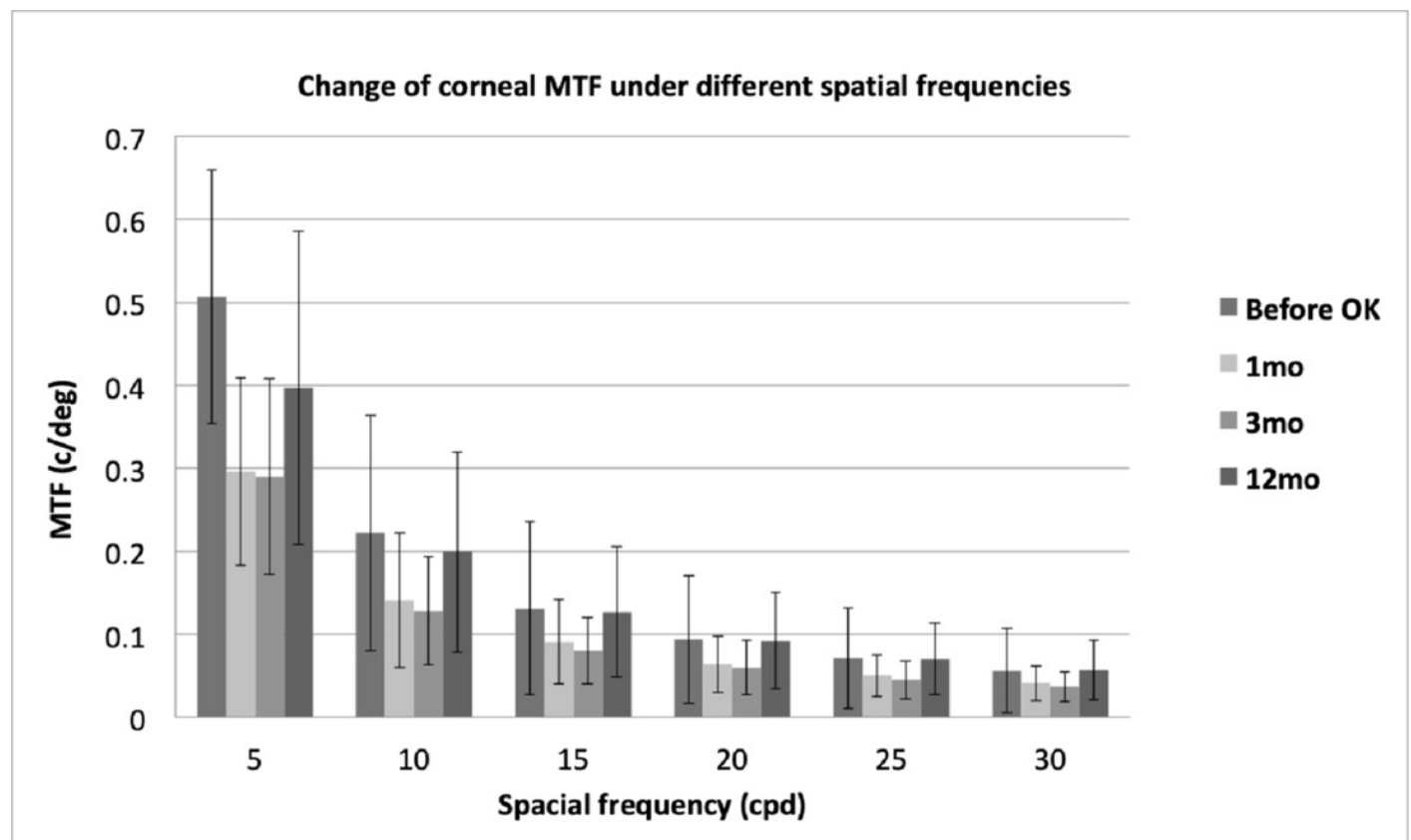



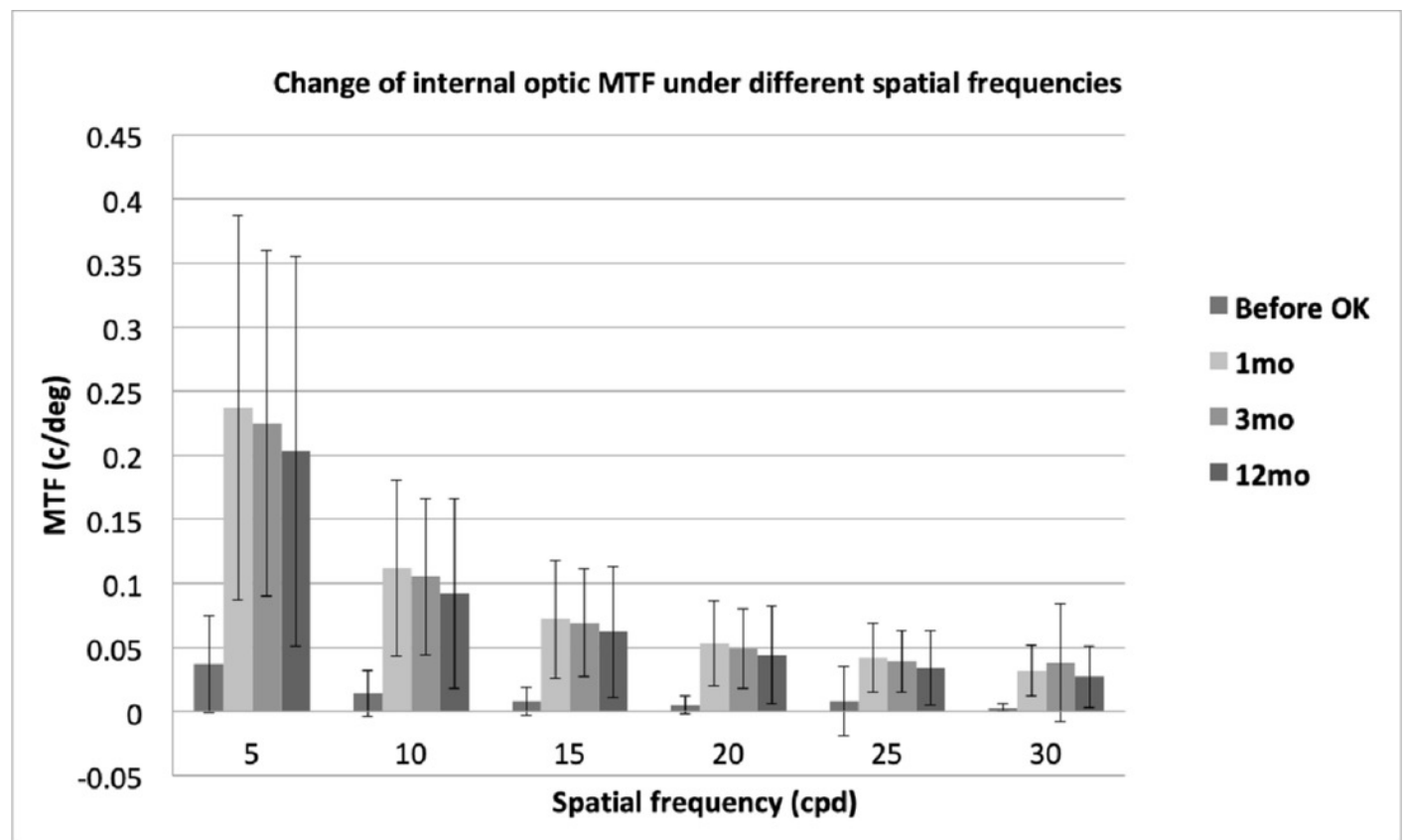
Figure 3

The evolution of internal optic MTF at different spatial frequencies before and at 1, 3, 12 months after wearing OK lens. Error bar: standard devision.

Change of internal optic MTF under different spatial frequencies

Change of internal optic MTF under different spatial frequencies

Legend: Before OK, 1mo, 3mo, 12mo

Y-axis: MTF (c/deg), X-axis: Spatial frequency (cpd)

Descriptive statistics (mean± SE) of myopic teenagers

* 4 eyes had astigmatism above -1.00D.

Comparison of corneal curvature, Q-value and e-value

The corneal curvature decreased significantly after wearing OK lens. Q-value increased at 1 month and decreased dramatically after 3 months. There were no significant differences for e-value before and after wearing OK lens. Data is expressed as mean±SD. * Compared with that before OK, *p>* adjusted alpha.

Table 2. Comparison of corneal curvature, Q-value and e-value

	Before OK	1 month	3 months	12 months	*p*
Horizontal corneal curvature, D	41.065±1.781	40.273±1.420	40.384±1.336	40.258±1.357	＜0.001
Vertical corneal curvature, D	43.354±2.075	41.406±1.419	41.219±1.942	41.320±1.859	＜0.001
Q-value	-0.203±0.186	0.375±0.643	0.224±0.523	0.202±0.532	＜0.001
e-value	0.482±0.129	0.528±0.211*	0.480±0.180*	0.424±0.210*	0.397

1 Table 2: The corneal curvature decreased significantly after wearing OK lens. Q-value increased at 1 month and decreased

2 dramatically after 3 months. There were no significant differences for e-value before and after wearing OK lens. Data is

3 expressed as mean±SD. * Compared with that before OK, *p*> adjusted alpha.

Comparison of SR and MTF

There were no significant differences of corneal SR before and after wearing OK lens, and the corneal MTF decreased after wearing OK lens significantly. After wearing OK lens the ocular and internal optic SR and MTF increased obviously. Data is expressed as mean±SD. *Compared with that before OK, $p>$ adjusted alpha.

Table 3   Comparison of SR and MTF

	Before OK	1 month	3 months	12 months	*p*
Ocular SR	0.001±0.001	0.017±0.019	0.028±0.033	0.017±0.026	<0.001
Corneal SR	0.051±0.048	0.027±0.020*	0.028±0.026*	0.031±0.023*	0.237
Internal optic SR	0.001±0.002	0.014±0.012	0.020±0.020	0.020±0.026	<0.001
Ocular MTF, c/deg	0.054±0.018	0.141±0.069	0.165±0.083	0.138±0.074	<0.001
Corneal MTF, c/deg	0.265±0.091	0.189±0.068	0.184±0.052	0.205±0.072	0.001
Internal optic MTF, c/deg	0.062±0.026	0.137±0.056	0.165±0.081	0.148±0.089	<0.001

1 Table 3: There were no significant differences of corneal SR before and after wearing OK lens, and the corneal MTF decreased

2 after wearing OK lens significantly. After wearing OK lens the ocular and internal optic SR and MTF increased obviously. Data

3 is expressed as mean±SD. *Compared with that before OK, *p*> adjusted alpha.

Comparison of ocular aberrations

After wearing OK lens the total HOA, spherical, coma and trefoil aberrations increased, and the total aberration, total LOA and defocus aberration decreased. Data is expressed as mean±SD. * Compared to that before OK, *p*> adjusted alpha.

Table 4   Comparison of ocular aberrations

	Before OK	1 month	3 months	12 months	p
Total aberration	2.446±1.055	1.518±1.038	1.564±1.164	1.741±1.326	<0.001
Total LOA	2.441±1.054	1.371±1.012	1.422±1.126	1.628±1.285	<0.001
Defocus	2.404±1.029	1.248±1.051	1.328±1.182	1.445±1.252	<0.001
Astigmatism	0.262±0.119	0.392±0.227*	0.364±0.215*	0.372±0.157*	0.017
Total HOA	0.141±0.068	0.496±0.488	0.511±0.328	0.497±0.492	<0.001
Spherical	0.032±0.037	0.180±0.191	0.189±0.145	0.194±0.182	<0.001
Coma	0.075±0.052	0.347±0.253	0.358±0.283	0.246±0.144	<0.001
Trefoil	0.049±0.026	0.109±0.092	0.137±0.091	0.108±0.084*	<0.001

2   Table 4: After wearing OK lens the total HOA, spherical, coma and trefoil aberrations increased, and the total aberration, total

3   LOA and defocus aberration decreased. Data is expressed as mean±SD. * Compared to that before OK, $p>$ adjusted alpha.

Comparison of corneal aberrations ations

The corneal aberrations increased significantly after wearing OK lens except astigmatism.

Data is expressed as mean±SD. * Compared to that before OK, $p>$ adjusted alpha.

Table 5   Comparison of corneal aberrations

	Before OK	1 month	3 months	12 months	p
Total aberration	0.544±0.213	1.187±0.980	1.199±0.601	1.372±2.038	<0.001
Total LOA	0.529±0.222	1.012±0.754	1.050±0.531	1.147±1.650	<0.001
Defocus	0.131±0.125	0.670±0.699	0.790±0.600	0.865±1.360	<0.001
Astigmatism	0.472±0.206	0.610±0.361*	0.492±0.199*	0.366±0.214*	0.040
Total HOA	0.108±0.037	0.587±0.657	0.544±0.346	0.717±1.220	<0.001
Spherical	0.033±0.026	0.151±0.122	0.175±0.114	0.211±0.376	<0.001
Coma	0.043±0.031	0.435±0.349	0.487±0.323	0.414±0.324	<0.001
Trefoil	0.058±0.029	0.116±0.070	0.134±0.076	0.111±0.075*	<0.001

1   Table 5: The corneal aberrations increased significantly after wearing OK lens except astigmatism. Data is expressed as

2   mean±SD. * Compared to that before OK, $p>$ adjusted alpha.

Comparison of internal optic aberrations

The total aberration, total LOAs and defocus aberration decreased significantly after wearing OK lens, and the total HOAs, spherical, coma and trefoil aberration increased significantly. Data is expressed as mean±SD. * Compared to that before OK, *p*> adjusted alpha.

Table 6   Comparison of internal optic aberrations

	Before OK	1 month	3 months	12 months	*p*
Total aberration	2.287±0.997	1.287±0.854	1.201±0.869	1.528±1.457	<0.001
Total LOA	2.309±1.029	1.150±0.874	1.087±0.894	1.278±1.132	<0.001
Defocus	2.273±1.035	0.584±1.212	0.584±1.185	0.570±1.469	<0.001
Astigmatism	0.320±0.123	0.426±0.253*	0.436±0.213*	0.331±0.174*	0.008
Total HOA	0.154±0.054	0.447±0.321	0.413±0.219	0.622±1.080	<0.001
Spherical	-0.001±0.037	0.030±0.136	0.013±0.092	-0.017±0.442	0.519
Coma	0.086±0.049	0.286±0.159	0.291±0.193	0.319±0.239	<0.001
Trefoil	0.074±0.026	0.166±0.118	0.148±0.092	0.112±0.073*	<0.001

1   Table 6: The total aberration, total LOAs and defocus aberration decreased significantly after wearing OK lens, and the total

2   HOAs, spherical, coma and trefoil aberration increased significantly. Data is expressed as mean±SD. * Compared to that before

3   OK, *p*> adjusted alpha.

Comparison of compensating factors and compensation rates for aberrations

The CF and CF% of total aberration, total LOA, total HOA and coma aberrations increased at 12 months. Data is expressed as mean±SD.

Table 7   Comparison of compensating factors and compensation rates for
aberrations

	CF		*p*	CF%	
	Before OK	12 months		Before OK	12 months
Total aberration	-4.013±2.532	-1.064±1.788	<0.001	0%	36.1%
Total LOA	-4.407±3.022	-1.390±2.155	<0.001	0%	30.6%
Defocus	-31.646±54.817	-32.438±166.855	0.979	0%	36.1%
Astigmatism	-0.329±3.271	-0.385±0.970	0.921	86.1%	38.9%
Total HOA	-0.379±0.719	0.082±0.435	0.001	33.3%	61.1%
Spherical	-0.679±3.793	-1.621±4.460	0.356	58.3%	36.1%
Coma	-1.894±2.538	0.226±0.542	<0.001	19.4%	66.7%
Trefoil	-0.177±0.974	-0.142±1.019	0.888	63.9%	63.9%

2   Table 7: The CF and CF% of total aberration, total LOA, total HOA and coma aberrations increased at 12 months. Data is

3   expressed as mean±SD.