Evaluation of Subjective Satisfaction with Orthokeratology: A Pilot Study

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Abstract
Background: This study evaluates subjective satisfaction levels among Singapore-based OK lens wearers and investigates what motivated them to go for OK.

Methods: A customised survey form was administered. Participants’ perceptions were assessed along the dimensions of vision, facial appearance, satisfaction, activity, and symptoms. The participants also had to indicate what motivated them to go for OK. The remaining questions focused on the participants’ demographics and OK related routines since the survey was designed to be a stand-alone questionnaire that is suitable for a specialised optometry setting.

Results: OK participants (n=100) demonstrated an overall positive experience across vision, facial appearance, satisfaction, and activity dimensions. Most participants either did not experience or only occasionally experienced the surveyed symptoms. Seeing clear throughout the day (71%), myopia control (70%), and convenience for school/occupation (65%) and sports (59%) were the most popular reasons why participants were on OK. Better appearance (36%), and discomfort with spectacles (34%) and contact lenses (11%) were the other motivating factors.

Conclusion: Orthokeratology is associated with high levels of satisfaction rate. Seeing clear throughout the day, myopia control and convenience for day-to-day activities are the key reasons why participants are on OK treatment. Optometrists, while ensuring rigorous compliance to lens care regimen and good adherence to routine follow-ups, may positively recommend orthokeratology not just for children for the purpose of myopia control but to potentially anyone, who wants to be free of day-time myopic refractive correction.

Keywords:
Orthokeratology, subjective satisfaction, myopia
Introduction

The prevalence of myopia – a global public health problem – is on the steady rise. It is predicted that nearly half the world’s population will have myopia by the middle of this century in which about 10% or nearly 1 billion people will have high myopia (Holden et al., 2016). High myopia is known to be associated with significantly higher risks of cataract, glaucoma, maculopathy and retinal detachment, some of the leading causes of irreversible vision loss (Wong et al., 2014). Slowing the progression of myopia through specialised contact lenses, ophthalmic lenses and/or pharmacologic interventions to potentially reduce the irreversible high-myopia associated vision loss, therefore, is progressively gaining momentum in clinical practice (Walline, 2016; Wolffsohn et al., 2020). Orthokeratology (OK) is one such specialised procedure where a rigid gas permeable lens is worn overnight to carefully reshape the cornea to not only correct myopia in the day but also to potentially control myopia (Bullimore & Johnson, 2020). OK is increasingly becoming popular among people with myopia including that of children, where myopia control is crucial.

Health-related quality of life instruments or questionnaires are known to reflect the impact of any treatment on people’s lives and daily functions. Likewise, vision-related quality of life (VRQOL) questionnaires are known to offer comprehensive patient-reported information about their own functional vision and well-being following any eye care procedures including that of OK treatment. Several researchers (Berntsen et al., 2006; González-Pérez et al., 2019; Lipson et al., 2004, 2005; Ritchey et al., 2005; Santodomingo-Rubido et al., 2013; Santolari et al., 2013; Yang et al., 2020; Zhao et al., 2018) have investigated VRQOL among OK participants, and have largely reported positive benefits in terms of vision, satisfaction, self-esteem, behaviour, and overall quality of life.

In Singapore, although the prevalence of myopia is one of the highest (Pan et al., 2012), unlike a decade ago (Leung, 2011), there has now been a growing interest in OK from eye care practitioners and potential lens wearers (Morgan et al., 2019); there has not been a formal research study among OK participants thus far. Therefore, this pilot study aims to evaluate the satisfaction levels among current OK participants and investigate what motivated them to go for OK treatment.

Methods

This was a cross-sectional study designed to evaluate satisfaction levels among existing OK lens wearers. Participants were recruited from a specialised commercial optometry practice when they presented for routine OK related aftercare visits as long as they were on OK treatment for at least 3 months. The research was conducted in accordance with the tenets of the Declaration of Helsinki and was approved by Singapore Polytechnic Institutional Review Board (IRB). Informed consent was obtained from the participants (and their parents, where needed) after they received a verbal and written explanation of the nature of the study.

Upon voluntarily signing the consent form, a customised OK-specific stand-alone survey questionnaire was administered to each participant using an online platform (i.e., google form); there were a total of 25 questions (see Appendix). The first 9 questions (Q1 to Q9) focussed on the participants’ demographics and OK related routines. The next question (Q10) focussed on what motivated the participants to go for OK. Questions 11 to 24 assessed OK participants’ subjective perceptions along the dimensions of vision, facial appearance, satisfaction, activity, and symptoms in the form of Likert-type questions. There were five options for each Likert-type question (e.g., very satisfied, somewhat satisfied, neither satisfied nor dissatisfied, somewhat dissatisfied, very dissatisfied for Q11); a small number of questions had an additional not-applicable option for the participants to choose (e.g., very happy, somewhat happy, neither happy nor unhappy, somewhat unhappy, very unhappy, not applicable for Q14). The final question (Q25) was an open-ended optional question that sought general feedback about OK experience. Since OK lenses are predominantly used by children, the survey was designed such that parents, where needed, could jointly complete the survey questions together with their children once both of them consented to voluntarily participate in the study.

Three domain experts (including two authors of this study and a neutral optometry academic) assessed the content and face validity of the study questions since existing validated VRQOL questionnaires were not used here for the following reasons: This is a cross-sectional study, where we surveyed existing
OK lens wearers presenting to a commercial optometry practice for routine aftercare visits. The survey form was personalised to be a stand-alone questionnaire to collect the data (including motivation for OK together with an open-ended question to receive any feedback on OK treatment) with a focus on relevance to a clinical setting rather than a research setting while still offering participant anonymity.

**Statistical analysis**

All automatically downloaded data from google platform were verified and transferred into a spreadsheet, and statistical analyses were performed using Minitab 18 software (Minitab, Pennsylvania, USA). Most data are presented using descriptive statistics since Likert-type questions have been used (Boone Jr. & Boone, 2012). Chi-square tests were used, where appropriate, to test for the difference in categorical responses with $\alpha$ set at 0.05.

**Results**

A total of 100 OK lens wearers voluntarily participated in this study. All of them had completed the survey questionnaire. As seen in Figure 1, there were 65 children (≤16 years old) and 35 adults (>16 years of age); note that ≤16 years old are termed here as children in line with the local optometry practice guidelines (see: www.ohh.gov.sg).

The mean age of participants was $24 \pm 11$ (in SD) years among adults while it was $13 \pm 2$ (in SD) years among children. The proportion of females ($n=31; 48\%$) and males ($n=34; 52\%$) were similar in the children group while there were significantly ($p<0.05$, $\chi^2=4.83$) more females ($n=24; 69\%$) than males ($n=11; 31\%$) in the adult group.

Figure 1: Study participants’ age (Q2) and gender (Q3) distribution.

Eighty-eight percent of the participants were students while the remaining 12% were working professionals (Q4). While we have significant number of younger participants in this study, only 3% needed help from their family members to insert and remove their OK lenses (Q9). Note that since the study recruited exactly 100 participants, all the numbers in the subsequent figures and text are interchangeably presented as numbers or in percentage in this manuscript.

Based on the right eye (RE) data, the proportion of low (<3D), moderate (3 to <6D) and high (≥6D) myopia were 50, 42 and 8 percent, respectively (Figure 2, doughnut chart); note that only RE data are used throughout this report for any comparative analysis. While all participants met the inclusion criteria of a minimum of 3 months of OK wear (Q1), 65% of the subjects had worn OK lenses between 1 and 6 years, and another 10% had worn for >6 years (Figure 2, middle pie chart). Eighty-six percent of the participants reported using OK lenses for either 6 or 7 nights per week (Figure 2, right pie chart).
Myopia control, seeing clear throughout the day and convenience for sports/school/occupation were the most popular reasons why participants were on OK (Figure 3). Myopia control was chosen as a reason by 74% and 63% of children and adults, respectively; further probing of the adult data indicates that 16 participants (between the age of 17 and 20), many of whom started OK when they were young, predictably chose myopia control as a reason. Among those who chose myopia control, 64% were from low myopia category, 74% were from moderate myopia category, and 88% were from high myopia category. Better appearance, and discomfort with spectacle and soft contact lenses (SCLs) were the other reasons why participants were on OK.

As seen in Figure 4, >90% of the OK participants were contented with their vision (Q11 to Q13), facial appearance (Q15) and satisfaction (Q16) level; their level of participation/enjoyment in (indoor/outdoor) activities was also equally good (Q20).
Eighty-six percent of the participants felt able to do things they wanted without spectacles (Q21) while 73% felt more self-confident because spectacles were not needed (Q22); further probing of the remaining 14% and 27% data revealed no significant association with gender, age group, and level of myopia.

There was a significant difference (P<0.05, $\chi^2=70.44$) in happiness ratings about facial appearance between OK (93%) and spectacles (38%), indicating far more happiness with OK treatment (Q14 & Q15). Further probing of the remaining 62% of the participants, whether it was the neutral and/or unhappy category, revealed no significant association with gender, age group, and level of myopia. As for the number of times participants engaged in outdoor activities before (Q18) and after (Q19) the OK treatment, although about 90% of the participants were engaged in some form of outdoor activities, there was no significant increase in the number of days they spent outdoors after the OK treatment.

As seen in Figure 5, ≥90% of the participants either did not experience or only occasionally experienced nine of the 11 symptoms surveyed. Eighty-one percent and 89% indicated similar responses for the symptoms dryness and irritation, respectively. Nevertheless, it is to be emphasized that about 40% of them occasionally experienced symptoms such as itchiness, dryness, redness, pain and irritation.
Further probing of the symptoms data, where one or more symptoms were reported in the scale of often to always, did not reveal any significant association across all the dimensions (e.g., gender, age group, refractive error magnitude, etc.) studied here, with the exception of the following observations: Five out of 9 (56%) participants, who reported glares/halos had ≥5D of myopia; note that there were 18 participants with ≥5D of myopia (Figure 2, doughnut chart) implying that glares/halos were seen only among 28% (5 out of 18) of them. Among the 19 participants with dryness, 12 were adults and nine out 12 (75%) were females. Five out of 14 (36%) participants, who reported redness, were somewhat worried about eye infections (Figure 6). One participant, who was very much worried about eye infections, reported pain often. A 11-year-old participant, who was on OK for >4 years, reported 9 out of 11 symptoms either often or always; the participant was the only one, who used OK for 3 nights a week (Figure 2, right pie chart). There were no significant associations across all dimensions when the symptoms were rated as occasional. Seeing floaters, potentially unrelated to OK, was indicated as the only symptom that was always present under the others category by a 16-year-old participant with high myopia.

Regarding the open-ended final question (Q25), where participants had the opportunity to share their overall experience with OK, there were 29 comments from 25 participants (12 adults and 13 children). Eighteen of those comments were positive (some examples: perfect solution, convenient, best in the universe, highly recommended, very comfortable, helpful for sports, etc) while 11 indicated their challenges (some examples: early stage discomfort, highly recommended only if one could afford, initial challenges with insertion and removal of the lens, worried about infection, etc.).

As seen in Figure 6, 71% were not worried about eye infections while 15% were worried. A vast number of participants (94%) were likely to recommend OK to a friend or a family member; when the data of 6% of the neutral participants were probed further, there was no association with any other survey findings; all of them were very satisfied (Q15) with OK though.
Figure 6: Responses on whether participants were worried about eye infections (Q24), and how likely they would recommend OK to a friend or family member (Q17).

Discussion

This study among existing OK lens wearers demonstrates an overall positive experience across vision, facial appearance, satisfaction, and activities dimensions. Majority of the participants did not report any symptoms with OK treatment. Myopia control, seeing clear throughout the day and convenience for sports/school/occupation were the most popular reasons why participants were on OK; better appearance, and discomfort with spectacle and contact lenses were the other popular reasons.

With regard to vision, satisfaction, activities and symptoms, the observed findings in this study are nearly in agreement with several previous studies. Lipson et al. (2005) reported that participants experienced lesser activity limitations, symptoms (with the exception of glare) and dependence on correction with OK lenses when compared to daily wear SCLs; about two-third of the participants indicated they would prefer to continue with OK over SCLs in their randomized 8-week-long crossover study. Note that the current study is a non-comparative study that focused only on existing OK lens wearers. Ritchey et al. (2005), in their 3-month-long study, reported that OK and extended wear SCL participants performed similarly across scales with the exception of dependence-on-correction scale, where OK group reported significantly improved QOL. Berntsen et al. (2006) compared QOL before and after one month of OK and reported that OK lenses improved participants' visual independence and reduced the amount of symptoms experienced (with the exception of glare); increased glare following OK was attributed to increase in the measured spherical aberrations. Rubido et al. (2013), in their 24-month-long study, reported that children in the OK group had superior QOL than that single vision spectacle group. Yang et al. (2020) also reported superior QOL among OK group, when compared to single vision spectacle group, when children were on OK for between 12 and 18 months duration; they reported that 30 to 40% of OK participants reported occasional symptoms such as discomfort, itchy/burning/dry eyes, and foreign body sensation. This observation concurs with this study in which ~40% of the study participants occasionally experienced symptoms such as itchiness, dryness, redness, pain and irritation. Zhao et al. (2018) compared before and after 3-months of OK among children and reported significantly better VRQOL, behaviours and psychology following OK; the children were reported to be “more self-confident, more willing to try new things, and more active in sports/entertainment, all of which resulted in an increasing trend of the total time spent on outdoor activities.” This study did not observe any self-reported increase in the number of days spent outdoors following OK.

While some studies (Berntsen et al., 2006; Lipson et al., 2005) reported glare following OK, 91% of the participants in this study did not report glare or halos (Figure 5). Santolaria et al. (2013) observed that light distortion seen under low-light conditions following OK is transient in nature since most participants reported an improvement after the first weeks of treatment. Inclusion criterion in this study was that all participants had to be on OK treatment for at least 3 months prior to enrolment. Indeed, 96% of them (Figure 2) had been on OK for >6 months duration in this study, which could imply that either the symptom resolved on its own or it was never present. Santolaria et al. (2013) also observed that older participants needed longer time to adapt. Yang et al. (2020), based on their clinical experience, indicated that younger
participants tend to be less sensitive to glare and halos. Nevertheless, in this study, there was no observation of any trend with the age, the magnitude of refractive error, or the number of nights the lenses are worn. Further research along pupil size, higher order aberrations, treatment zone size, the magnitude of refractive error, and age may provide more information regarding glare or halos among OK participants.

While this study did not seek feedback on near and far vision satisfaction with OK separately, Rubido et al. (2013) reported that near vision was worse with OK compared to single vision spectacles. They postulated that it could be due to the greater demands for accommodation since over-correction is needed for OK fit to account for the diurnal regression of corneal curvature. Nevertheless, >90% of the existing OK participants in this study indicated that their vision was good, stable and comparable to spectacles (Figure 4) while not reporting blurry vision as a symptom (Figure 5).

Only about 15% the participants in this study indicated that they were worried about eye infections. Liu and Xie (2016) reported that OK is a safe option for myopia control and that the long-term success is achievable with rigorous compliance to lens care regimen and good adherence to routine follow-ups. Almost all participants (94%) in this study were likely to recommend OK to a friend or a family member, which might further imply that they were satisfied with the overall OK treatment (Figure 6).

Myopia control and seeing clear throughout the day are the two most popular reasons why majority of the participants were on OK (Figure 3) in this study. While the choice of myopia control as the reason among majority of the children is understandable, 22 out of 35 adults’ same choice needs a brief mention here. Many of them had been on OK from young age, which might suggest that they would have started OK treatment mainly for the purpose of myopia control. Since many of them also indicated seeing clear throughout the day, convenience for sports/school/occupation and better (cosmetic) appearance as the other reasons, it is reasonable that they continue with OK into their adulthood. These observations are comparable to the findings of Zhao et al. (2018).

Discomfort with spectacles (34%) and SCLs (11%), and atropine eye drops (only one participant) were the other reasons why participants were on OK. Nine out of 11 subjects that indicated discomfort with SCLs are adults; beyond OK, this might imply that lenses in general are still predominantly worn by adults although this trend is likely to change with time due to significant increase in myopia prevalence rates among children and the need to control myopia with OK or SCL and other evidence based treatment options. It is noteworthy to also indicate that 4% of the study participants were into their presbyopic age group (Figure 1), which might further imply that OK might be an option for any age group. Therefore, the study findings further confirm that OK may be an effective option not just for myopia control among children but also to provide unaided visual freedom in the daytime for a wide range of refractive corrections across different age groups.

Limitations of the study

While this pilot study has the strength of having a large number of authentic OK participants, one of the major limitations is that the customised survey questionnaire used here has not been adequately validated. The survey was personalised to be a stand-alone questionnaire to collect appropriate data (including motivation for OK together with an open-ended question to receive any feedback on OK treatment) with a focus on relevance to a clinical rather than a research setting while still offering participant anonymity. Three domain experts (including two authors of this study and a neutral optometry academic) assessed the content and face validity of the study. The reliability analysis using Cronbach's Alpha, post data collection, was found to be only 0.5 for the questionnaire used here. To allow for good reliability, Cronbach's Alpha is required to exceed the value 0.7 (Yang et al., 2020). While this is the first local study among OK participants with good overall satisfaction ratings with OK treatment, the results collected from a single established optometry practice may not entirely represent the whole of Singapore. There is, therefore, a need to conduct studies using a validated questionnaire across a few different sites to generalise the results. Similarly, the authors of this study plan to conduct future studies using appropriate validated questionnaires among different groups of participants (e.g., adults, children, etc.). While this study collected data on authentic existing OK participants, there were no attempts to compare within the same group of participants before and after OK nor were there conscious attempts to interview
participants, who might have dropped out of OK treatment due to any significant symptoms or dissatisfaction. The authors plan to address some of these research questions by adopting validated questionnaires in the future studies.

**Conclusion**

Orthokeratology is generally associated with high levels of satisfaction rate. Seeing clear throughout the day, myopia control and convenience for day-to-day activities are the key reasons why participants are on OK treatment. Optometrists, while ensuring rigorous compliance to lens care regimen and good adherence to routine follow-ups, may positively recommend orthokeratology not just for children for the purpose of myopia control but for anyone with myopia, who wants to be free of refractive correction during the day.

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Financial disclosure statement
No potential conflict of interest reported by the authors JL and NR. TW is a consultant at Titus Eye Care and is not directly involved with the recruitment of the study participants.

Appendix:
The customised questionnaire used in this study.
General information
Q1. Are you wearing orthokeratology lenses for at least 3 months?
Q2. What is your (or your child’s) year of birth?
Q3. What is your (or your child’s) gender?
Q4. What is your (or your child’s) occupation?
Q5. How long have you been wearing orthokeratology lenses?
Q6. What was your approximate spectacle power (i.e., myopia degree) in your Right Eye before you started orthokeratology lens? You can ignore astigmatism.
Q7. What was your approximate spectacle power (i.e., myopia degree) in your Left Eye before you started orthokeratology lens? You can ignore astigmatism.
Q8. On average, how many nights a week do you wear your orthokeratology lenses?
Q9. Orthokeratology lenses are inserted and removed from your eyes by _______.

Reason
Q10. What motivated you to go for orthokeratology? More than 1 option can be ticked. (List of options is given in Figure 3)

Vision
Q11. In general, how would you rate your vision after wearing orthokeratology lenses?
Q12. In general, how good is your vision after orthokeratology (compared to previous spectacle or other refractive correction)?
Q13. In general, how would you rate the stability of your vision (i.e., no fluctuations in vision) after wearing orthokeratology lenses?

Appearance
Q14. In terms of facial appearance, how happy were you when wearing of spectacles?
Q15. In terms of facial appearance, how happy are you to be free of spectacles during the day because of orthokeratology?

Satisfaction
Q16. How satisfied are you with your orthokeratology treatment so far?
Q17. How likely would you recommend orthokeratology to a friend or family member?

Activities
Q18. In general, about how many times in the average week did you engage in outdoor activities (e.g., sports, jogging, etc.) before orthokeratology?
Q19. In general, about how many times in the average week do you engage in outdoor activities (e.g., sports, jogging, etc.) after orthokeratology?
Q20. After orthokeratology, you are able to enjoy / participate in indoor / outdoor activities better.
Q21. After orthokeratology, how often have you felt able to do the things you want to do without spectacles?
Q22. After orthokeratology, you feel more self-confident because you do NOT need to wear spectacles.

Symptoms
Q23. Any of these symptoms bother you when wearing orthokeratology lenses. (List of symptoms is given in Figure 5)
Q24. With orthokeratology, how worried are you about eye infections?
Q25. Any other comments about your experience with orthokeratology (open-ended optional question).
References


