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Original Article

Comparison of Self Refraction accuracy with Cycloplegic Subjective Refraction in Young Adults

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Abstract

Background: Uncorrected refractive error is one of the major causes of blindness. Self-refraction methods are currently practiced to correct refractive error. Self-adjustable eyeglasses are available easily in the present online buying era. Hence this study aimed to compare the visual and refractive outcomes between Self-refraction (SR) eyeglasses and Cycloplegic subjective Refraction (CSR).

Methodology: This observational cross-sectional study included 59 participants (21 males and 38 females) within the age of 18 to 30yearsand refractive error between +3.00D to -6.00D took part in this study. Subjects with a previous history of non-strabismic binocular vision anomaly, astigmatic error, pathological eye problems, ocular surgery or trauma were excluded from the study. The subjects were allowed to estimate their refractive error with DialVision eyeglasses followed by CSR, which was performed by a single examiner. The visual and refractive outcomes of SR and CSR were collected and analyzed.

Result: The study participants mean age was 22(2) years.The comparison of visual acuity and duochrome between SR and CSR using Paired T test showed a statistically significant difference (P<0.01). Visual acuity attained from SR resulted in a mean acuity of 0.14(0.05) logMAR compared to CSR 0.002(0.007) logMAR. Duochrome test identified 92% of participants being under corrected with SR. No statistically significant difference was observed in contrast sensitivity and cover test (P>0.01).

Conclusion: Visual acuity with SR was acceptable but wasn't better than CSR. Appreciable under correction of refractive error with SR raises concern. Encouraging a patient to correct their own refractive error without a comprehensive eye examination can lead to various adverse effects. Even though SR might bring a brief relief towards the burden of uncorrected refractive error, dispensing spectacle based on standard refraction procedure is imperative for good visual performance.

Keywords: Self Refraction; Cycloplegic Subjective Refraction; Myopia; Refractive Error; Duochrome.

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Introduction

Uncorrected refractive error (URE)is one of the leading causes of visual impairment.[1] World Health Organization (WHO) during the Global action plan 2014 - 2019 estimated that, globally 2.2 million people were visually impaired.[2] URE can affect a person's educational performance, employment, independent living and quality of life. Myopia is the most common refractive error prevalent among school aged children.[1] India accounts to a major proportion of children being inadequately corrected for refractive error.[3,4] In management of URE, cycloplegic subjective refraction is considered as the gold standard for prescribingspectacleespeciallyforyoungmyopicandhyperopicpopulations.[5-8] Recent technologies have brought in self-adjusting spectacle such as AdSpecs and Dial Vision. These adjustable focus eyeglasses can be used to correct their refractive error. Various studies have reported optimal vision with the self-adjusting spectacle.[3,9] Eye care professional and system to offer refraction services are being limited in the developing world.[9,10] Lack of spectacle correction in people due to unaffordable cost and inaccessibility are cited reasons for the development of self-refraction spectacle.[11] Hence, availability of self-adjusting spectacle are said to reduce the burden of uncorrected refractive error especially in rural areas.

Self-adjustable eyeglasses

At present there are few self-adjustable eyeglasses available, where it is marketed to correct refractive error for distance vision, presbyopia for near vision (both only spherical powers) and the tool is recommended for use of children and adults.[3,10] The individual requiring refractive correction can adjust their refractive power by themselves using the self-adjustable spectacle (self-refraction). Self-adjustable spectacle works under different mechanisms such as 1) Fluid filled 2) Dual lens technology and 3) SR using refraction bar. Spectacles which work on fluid filled technology have been used in previous studies predominantly.[3,9,12,13] The one used in our study was dual lens technology as it functions with two lenses. One lens is movable, and the other lens is non-movable. The movable lens slides across when the small knob of the frame is rotated and the position of the two lenses determines the refractive power (Figure 1). This lateral shifting of one lens is the key source of change in optical power.[11]In dual lens technology, the curvature varies significantly across the lens, so the determination of lens power is not possible through lensometer. This working mechanism is assumed to be developed from the Alvarez principle.[11] Many SR spectacle are available in developing countries, but no information is available about their optical design.[11] The Dial Vision eyeglass used in this study is marketed for refractive error between +3.00D to -6.00Dand not for astigmatism. The self-adjusting spectacle are operated in such a way that each of the right and left eye lens is adjusted separately for achieving the desired correction and vision.[3]

Self-refraction raises the possibility of the individual either over correcting or under correcting their refractive error. Over correcting myopia will cause eye strain and ocular fatigue especially in young myopes who works on visual display unit (VDU) for a long period of time and has the possibility of developing esophoria whereas, under correcting myopia will affect the binocular visual acuity and tends todevelopexophoria.[14] Under correcting hyperopia will affect the distance-near relationship and accommodation process leading the individual to squeeze their eyes in order to look at a target and likewise has a chance of developing non strabismic binocular vision anomaly such as accommodative in-sufficiency.[15,16] Hampering the accommodation process by under correcting hyperopia leads to asthenopia, eye fatigue associated with near point task, difficulty with attention and concentration while reading.[17] Appropriate correction of refractive errors and ideal spectacle dispensing is a foremost role of an eye care practitioner (ECP), whereas self-adjustable eyeglasses at present raises several concerns as it is used as a substitute for spectacles to correct refractive errors. Conversely observing almost no studies on Dial Vision eyeglasses and lack of tests such as duochrome and contrast sensitivity led us in comparing the visual & refractive outcomes between SR and cycloplegic subjective refraction.

Subjects and Methods

Materials used: Complete refraction setup with LogMAR chart, Self-adjustable eyeglasses, Cyclopentolate and tropicamide eye drops.

Methodology

This observational cross-sectional study was carried out with approval from the institutional research and ethics committee REF NO: IEC CSP/19/MAY/77/172 in a tertiary hospital and adhered to the tenets of the Declaration of Helsinki. Participants were enrolled in the study after their consent. Hundred and eighteen eyes of fifty-nine participants of young myopes and hyperopes aged between 18 to 30 years were eligible to take part in this study. Non-probability sampling was used to involve the participants in the study. Patients with myopia and hyperopia between the refractive error of +3.00 D to -6.00 D and patients without any pathological eye diseases were the inclusion criteria. Patients with the refractive error of greater than +3.00D and -6.00D, ametropes with astigmatism and patients with the history of non-strabismic binocular vision anomalies (NSBVA) were the exclusion criteria.

All recruited participants underwent the following sequence of examinations. Participants history was collected by the examiner including chief complaints and ocular health followed by visual acuity examination monocularly. The participants were allowed initially to perform self-refraction with Dial Vision eyeglasses. Visual parameters such as visual acuity, duochrome, contrast sensitivity and cover test were assessed and recorded. Four set of steps were followed for SR with Dial Vision. Step 1: The participant was made to sit in front of a LogMAR chart and wear the self-adjustable spectacle. Step 2: Occlude the left eye and use the right adjusting knob to focus onto the best possible line which can be read in the LogMAR chart. Step 3: Occlude the right eye and use the left adjusting knob to focus onto the best possible line which can be read in the LogMAR chart. Step 4: Use both the adjusting knobs to fine tune the vision followed by documentation of VA (Figure 2). Duochrome, contrast sensitivity and cover test were performed sequentially. Subsequently cyclopentolate, tropicamide and cyclopentolate (CTC) all of 0.5 % were instilled in both the eyes at an interval of 5 min and cycloplegic objective refraction was performed after 30 min. Participants underwent Post mydriatic test (PMT) after 3 days and the same visual parameters were assessed and noted for data analysis. The flowchart of methodology is depicted in ‘Figure 3’.

Statistical analysis: The collected data was analysed with statistical package for the social sciences (SPSS) 23.0 version (IBM Corporation, New York, USA). The data was checked for normal distribution with Shapiro wilk test. Paired T test was used to find out the difference in visual and refractive outcomes between SR and CSR as the data was normally distributed. McNemar test was used to compare the cover test between SR and CSR.

Results

118 eyes of 59 participants which included 21 males (36%) and 38 females (64%) with a mean (SD) age of 22 (2) years ranging between 18 to 30 years participated in the study. Among the participants, 47 (80%) were graded as mild myopic (-0.25D to -3.00D) and 12 (20%) were moderate myopic (-3.25D to -6.00D). The CSR values ranged from-0.50D to -6.00D with a mean of -2.14 (1.47) dioptres. Our study sample didn’t have any hyperopic participants. None of the participants had previously used self-adjustable glasses. The mean and SD for visual acuity attained with SR was 0.15 (0.04) logMAR and CSR was 0.002 (0.007) logMAR. Comparing the visual acuity between SR and CSR showed a statistically significant difference (P = 0.000). The range of visual acuity attained with SR resulted between (0.2 to 0.00) logMAR equivalent to (20/32 to 20/20). 52 (88%) participants achieved a visual acuity range between 0.2 to 0.1 logMAR (20/32 to 20/25) with SR and the remaining 7 (12%) participants attained visual acuity between 0.06 and 0.0 logMAR (20/20). Conversely, all the participants achieved a visual acuity range of 0.06 to 0.0 logMAR when performed CSR. Comparison of duochrome between SR and CSR revealed a statistical significance (P = 0.000). Duochrome responses indicated that 92%of participants were under corrected (red better) and 8% reported balanced with SR. Whereas, 96% of participants reported balanced with CSR signifying ideal spectacle correction and 4% reported red better. Contrast sensitivity of SR was 1.94 (0.03) logMAR and CSR 1.95 (0.02) logMAR respectively. The mean values represent normal contrast sensitivity and when compared it showed no statistical significance (P = 0.319). Similarly, no statistical difference was observed with cover test between SR and CSR (P =1.000). This meant, no change in phoria between SR and CSR. 95% of participants were orthophoric and rest of the 5% were exophoric.

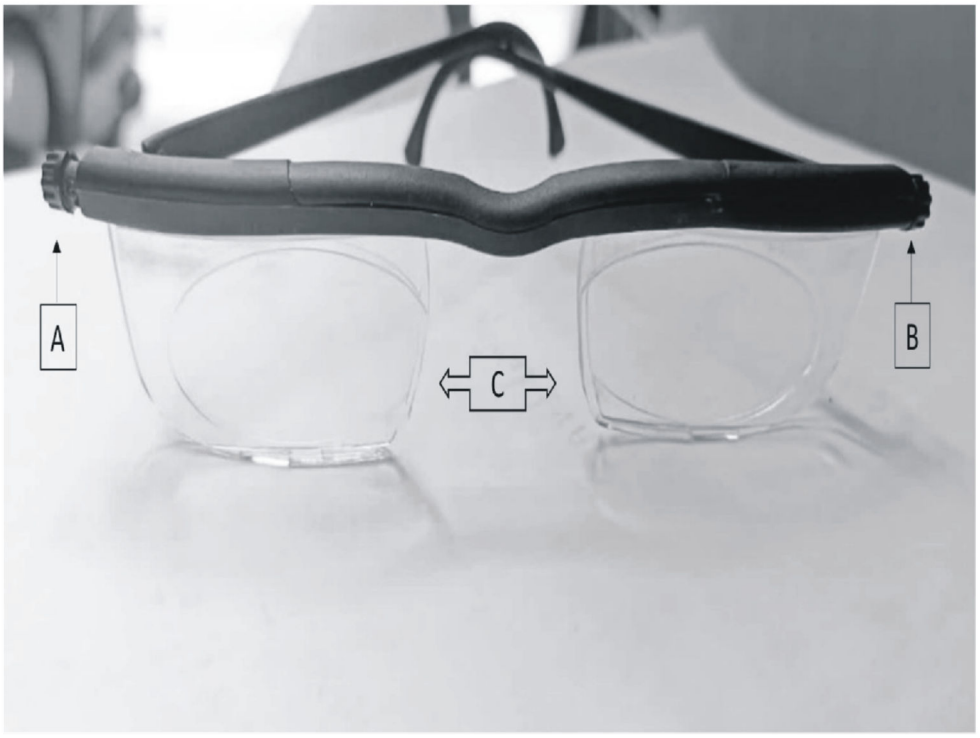

Figure 1: DialVision Eyeglasses
A: Right adjusting knob, B: Left adjusting knob, C: Right and left dual lenses

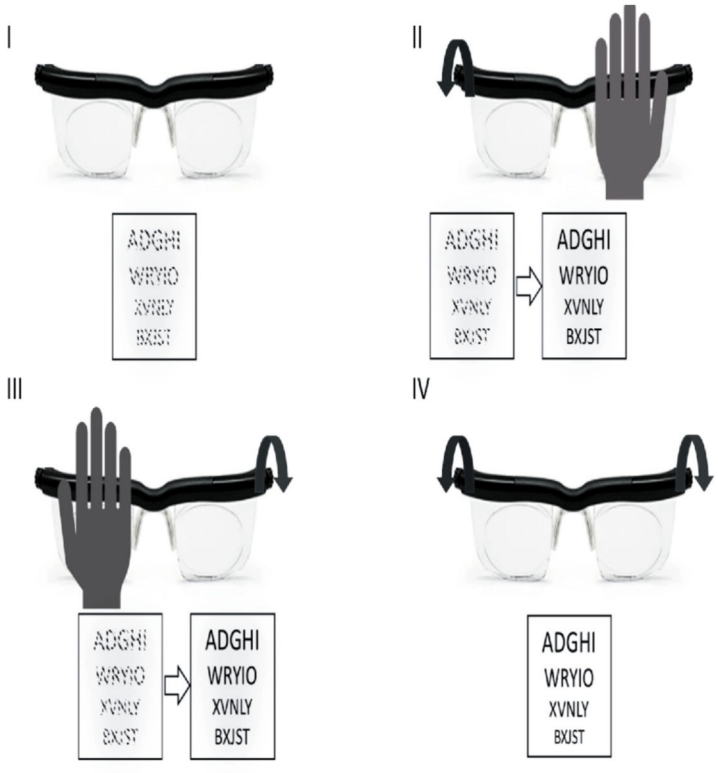

Figure 2: Steps involved in Self-refraction
I: Wearing DialVision eyeglasses and focus LogMAR chart, II: Occlude left eye and adjust right knob, III: Occlude right eye and adjust left knob, IV: Adjust both knobs to fine tune

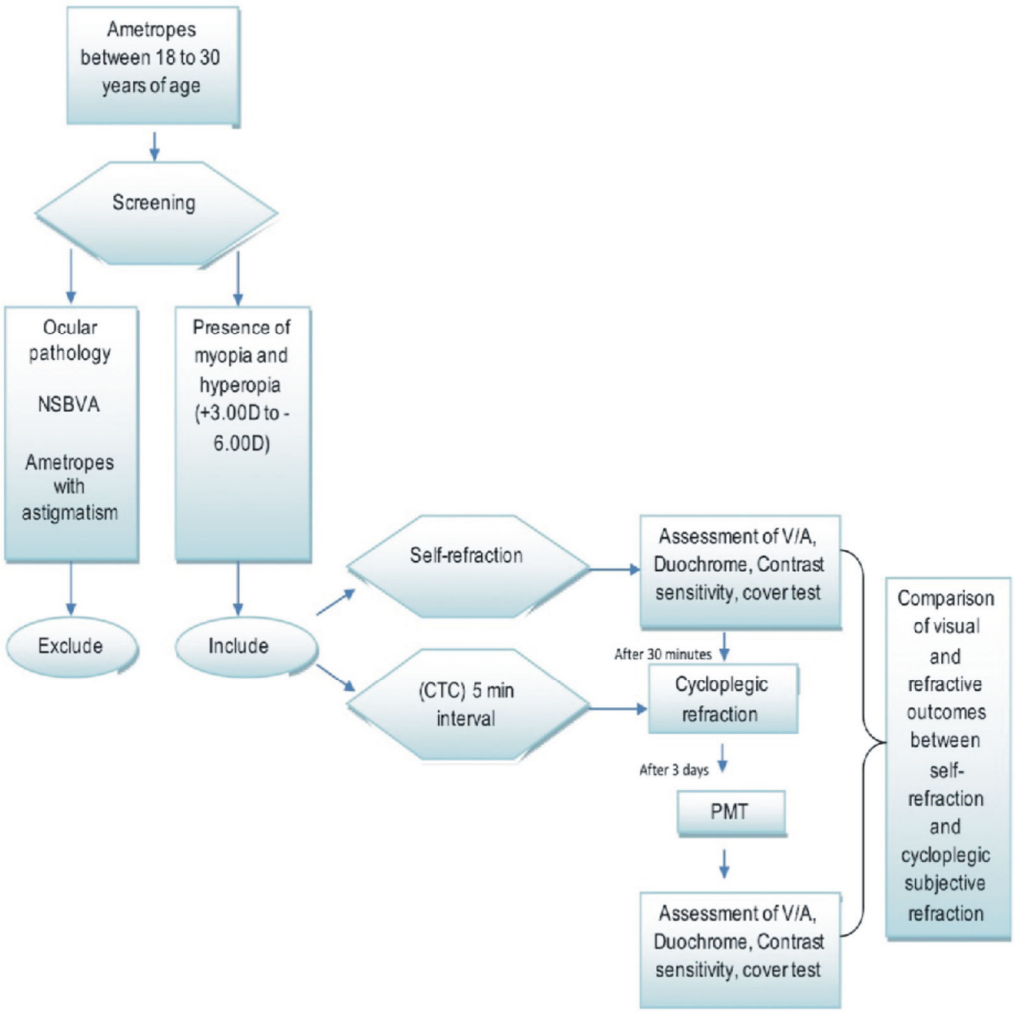

Figure 3: Methodology Flow chart
CTC: Cyclopentolate, tropicamide and cyclopentolate refraction, NSBVA: Non strabismic binocular vision anomalies, PMT: Post mydriatic test, V/A: Visual acuity

Discussion

To the best of our knowledge this is the first study to use DialVision eyeglasses. As per the results achieved in our study, we observed SR showed substantial visual acuity range between 20/32 to 20/20. 88% of the study sample achieved visual acuity between 20/32 to 20/25with SR, which is considered as an acceptable visual acuity range based on the cut-off value of a previous study.[18] The visual acuity observed with CSR showed all participants achieving almost 20/20 visual acuity. Though SR gave an acceptable visual acuity range, only 12% of our participants could achieve the best corrected visual acuity (BCVA) attained with CSR. This could be due to lack of good optical quality which should be achieved at different shift positions while adjusting the dial during self-refraction with DialVision eyeglasses.[11]

Most of the previous studies have not used the self-adjusting spectacle which works with dual lens as used in our study, hence a direct comparison of visual parameters was not possible. Smith et al study which has used AdSpecs reported that 88% and 66% of participants achieved 20/20 visual acuity in two different populations. Another study reported no major difference between subjective refraction and SR.[12] Study done in Ghana with self-adjusting spectacle reported 85% of subjects achieved visual acuity greater than or equal to 6/7.5 (20/25) which was quite similar to our study. The Ghana study also observed clinically significant difference in spherical equivalent refractive error between CSR and SR with myopia inaccuracy of greater

than 0.50D to ≥ to -1.00D.[8] Inappropriate correction of myopia and presence of blurred vision at any distance will increase the chance of myopia progression.[19] Francisco Gomez-Salazaret *et al* stated, inappropriate visual acuity will affect the quality of life among all age groups and also the socio-economicstatus.[20] Thus these can be considered as some of the risk factors which can be faced with self-adjusting spectacle. Estimation of dioptric value or the lens power of SR spectacle in our study was not possible as it was based on dual lens technology. Hence, we were not able to report the mean refractive values of SR. Earlier studies which have used liquid filled mechanism were able to estimate the dioptric power of the self-adjusting spectacle. [3,9,12,13]

Leung and Brown stated that full distance correction is required to slow down the progression of refractive error in young ametropes.[21]This scenario directed us to introspecton under correction and over correction of refractive error with duochrome as this has not been primarily considered by many of the earlier studies apart from one study. A complete CSR is an important procedure in determining and correcting any kind of refractive error in children and young adults especially those with higher amplitude of accommodation.[5-8] Our study showed a significant difference in duochrome with 92% of participants reporting red better with SR. Red better in duochrome indicates under correction of refractive error in myopes. Progression of myopia seems to increase when the refractive error is undercorrected.[19,22] Wearing under corrected spectacle can trigger problems like asthenopia especially while doing near work and working with VDU. It can also affect the binocular visual acuity which gives impact on the poor quality of life.[14,20] Though SR spectacle gave acceptable visual acuity range, under correction of refractive error becomes a concern. Refraction performed by an eye care professional gives an opportunity for a comprehensive eye examination, which aims to adequately correct the subject and even detect other causes of poor vision.[3] Observing the outcomes of our study, CSR provides accurate refractive error correction and its recommended especially in children and teenagers.[7]

There were several concerns raised previously with self-adjusting spectacle such as safety and stability of refractive error.[3] Concerns raised by previous study on the stability of refractive error with self-adjusting spectacle could be due to the inadequacy in refractive error correction. Over correction and under correction of refractive error will induce near phoria in myopic patients and particularly under correcting the myopes will end up with exophoria.[14]Chiranjib M et al says, exophoria may develop at a certain point when the myopes are being under corrected for a longer period of time.[14] Our study's participants neither had used SR before nor were wearing it constantly over a period of time. Hence no appreciable exophoria was observed. Understanding the other components such as safety, cost, functional and cosmetic acceptability of self-adjusting glasses like DialVision should be studied on long term basis.[3]

A previous study used USee device which works with dials that moves a refraction-lens bar to change the refractive power.[18] The USee device felt to be more sophisticated which consisted of EyeOpener kit, plastic frames, pop-in lenses and visual acuity chart. Though the working mechanism of USee device was different from our study, there was a significant difference in visual acuity (≥20/30) between self-refraction (83.3%) when compared to manifest refraction (96.7%). This was the only study which performed duochrome test and observed marginal responses. As per our knowledge, there is scarcity in literatures about self-adjusting spectacle working on dual lens mechanism. The optical and frame design behind eyeglasses like DialVision are not known. As Alvarez lenses can suffer from inherent problems like thickness away from the centre, a comprehensive approach towards designing these lenses have been proposed.[11] But it's truly unaware on how these changes are currently incorporated in designing dual lens self-adjusting spectacle. Future research with these types of spectacles can give better perspectives.

This study showed normal contrast sensitivity function with SR which might be due to the inclusion of low to medium myopes.[23]Further research in understanding visual functions with self-adjusting spectacle and self-refraction in subjects with high amplitude of accommodation can be a future scope. One of the limitations of our study were lack of hyperopes within the sample. Though many literatures suggest that there is close proximity with the VA achieved with SR and CSR, our study highlights some disadvantages

due to under corrected refractive error. Smith K et al says, although the mean value obtained through SR is somewhat closer to subjective refraction but clinically meaningful differences were observed between SR and CSR.[9] Myopicin accuracy in a negative direction has also been noted in few children's during SR.[8] Hence, SR spectacle cannot be considered as an ideal tool to correct refractive error for myopic children although it is said to be cost effective.[9] Performance of DialVision eyeglasses in school children and teenagers are yet to be studied limiting their recommendation. Sanfilippo PG et al study emphasizes the importance of cycloplegic refraction in teenagers between 13 to 19 years of age.[7]

Burden of uncorrected refractive error

As this study has reported acceptable visual acuity range with SR, it is important to note that many studies have recommended self-adjusting spectacle such as AdSpecs as a tool in places where there is a lack of refraction services and accessibility to eye care services especially among school children in rural areas as it provides acceptable vision.[3,9,12,13] Since children are vulnerable to uncorrected refractive error, it directly affects their learning and educational process. Hence availability to self-adjusting spectacle can fairly limit their visual inadequacy.[1,3,24]This could be a reason why self-refraction are still being considered for children and young adults as it offers a reasonably acceptable visual and refractive outcome compared to their unaided vision.[8] Countries like Ethiopia are already facing serious eye problems due to lack of eye care services.[1] India reports to 10.2% of adults with visual impairment and blindness from uncorrected refractive error and 33% with uncorrected presbyopia.[25] Assuming SR might bring a brief relief in managing the burden of uncorrected refractive error and presbyopia in rural areas, it further raises questions towards its common availability and accessibility, as it is predominantly available through E-commerce (online).[10,26] This might be a challenge for people living in rural areas to gain its access.

Conclusion

Visual acuity with SR was acceptable but wasn't better than CSR. Appreciable under correction of refractive error with SR raises concern. As under correction can lead to various adverse effects, prescribing spectacles through standard refraction procedure becomes imperative for good visual performance. Considering the global burden of uncorrected refractive error and visual impairment in countries like India, it still remains a fact that self-refraction with self-adjusting spectacle might alleviate the countries burden. Implementing primary eye care services in rural areas and providing optimal visual correction should always be aimed as a long-term goal.

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