International Journal of General Medicine

Dovepress
Taylor & Francis Group

Open Access Full Text Article

ORIGINAL RESEARCH

Refractive Errors and Ocular Biometric Parameters in Children with Autism Spectrum Disorder in Handan: A Cross-Sectional Study

Yueying Cheng[1–4,*], Junjun Wang[1–3,5,*], Mingmei Liu[1–3,*], Dengyuan Guo[4], Jinxia Yan[4], Limei Bai[4], Kefei Guo[4], Jingjing Wei[4], Yaling Zhang[4], Kai Yang[4], Yatu Guo[2,3], Wei Zhang[1–3]

[1]Clinical College of Ophthalmology, Tianjin Medical University, Tianjin, People's Republic of China; [2]Tianjin Key Laboratory of Ophthalmology and Vision Science, Tianjin Eye Hospital, Tianjin, People's Republic of China; [3]Nankai University Affiliated Tianjin Eye Hospital, Nankai University, Tianjin, People's Republic of China; [4]Optometry Center, Handan City Eye Hospital (The Third Hospital of Handan), Handan, People's Republic of China; [5]School of Medical Technology, Tianjin Medical College, Tianjin, People's Republic of China

*These authors contributed equally to this work

Correspondence: Yatu Guo; Wei Zhang, Tianjin Eye Hospital, 4 Gansu Road, Heping District, Tianjin, 300020, People's Republic of China, Tel +86-22-27313336, Email yatuguo@163.com; zhangwei3067@163.com

Purpose: To investigate the differences in refractive status between children with autism spectrum disorders (ASD) and normal children, as well as the differences in the development of ocular characteristic parameters such as axial length(AL), in order to provide some help for eye care and subsequent rehabilitation in this group.

Patients and Methods: This cross-sectional study enrolled 95 children aged 4–12 years with ASD from the Handan region of China, along with 96 matched control children. All participants underwent non-cycloplegic ocular refraction and ocular biometric parameter measurements, aiming to explore the association between ASD and ocular refractive errors as well as ocular biometric parameters.

Results: Children with ASD exhibited significantly higher hyperopia, Spherical equivalent (SE: ASD 0.00 ±1.30 DS vs control −0.50 ±1.80 DS, $p < 0.01$), Cylinder (CYL: ASD −0.75 ±1.50DC vs control −0.50 ±0.50 DC, $p < 0.01$), shallower Anterior Chamber Depth (ACD) (ASD 2.93 ±0.26 vs control 3.03 ±0.34, $p < 0.05$) compared to controls. SE was negatively correlated with AL. The axial length-to-crane ratio (AL/CR), ACD, and vitreous thickness (VT) were positively correlated with lens thickness (LT) ($p < 0.05$). Logistic regression analysis demonstrated that SE, CYL, AL/CR, and ACD were associated with ASD (all p-values <0.05). The random forest model indicated that SE (25.5%) and ACD (25.3%) were the primary predictors of ASD.

Conclusion: The detection of ocular biological characteristic parameters has significant guiding significance for correcting refractive errors in children with ASD. Moreover, the combined diagnosis of SE, CYL, AL/CR, and may help identify children who may benefit from further ASD assessment. However, the predictive utility of these parameters requires validation in prospective, larger-scale studies.

Keywords: autism spectrum disorder, refractive errors, ocular biometry, spherical equivalent, anterior chamber depth

Introduction

Autism spectrum disorder (ASD) is a complex neurodevelopmental condition marked by ongoing challenges in social interaction and communication, along with restricted and repetitive behaviors.[1] These core characteristics usually appear in early childhood and impact various developmental domains, including cognitive, sensory, and motor functions.[2] Recent epidemiological studies reveal a rising global prevalence of ASD, with US estimates indicating that 1 in 36 children is diagnosed with the disorder.[3–5] A similar trend is observed in China, where some studies estimate the prevalence among children to be around 1%.[6,7] Although the precise causes of ASD are complex and involve genetic, epigenetic, and environmental factors, there is a general consensus on the critical role of early and accurate diagnosis.[8–10]

https://doi.org/10.2147/IJGM.S572336
Received: 20 November 2025
Accepted: 8 March 2026
Published: 27 March 2026

Detecting ASD early allows for the implementation of evidence-based interventions, significantly improving developmental outcomes and quality of life for children with ASD and their families.

In addition to the well-known challenges in behavior and social communication, children with ASD often display distinctive sensory processing patterns that can affect visual function.[11,12] Research worldwide consistently shows a higher incidence of visual impairments in this group: systematic reviews reveal that 22.5–44% of children with ASD have clinically significant refractive errors, with astigmatism being particularly more common compared to that in neurotypical children, although rates of myopia and hyperopia are similar to those in the general pediatric population.[13–18] In China, a cross-sectional study of 292 children with ASD and intellectual disability in Beijing found astigmatism and ametropia in 45.1% and 47.2% of eyes, respectively, with 57.7% of refractive errors remaining uncorrected despite clinical need.[19] Similarly, a Taiwanese study involving 3551 children with ASD revealed an increased risk for amblyopia, anisometropia, and strabismus.[20] These findings indicate that refractive issues may be more prevalent in ASD populations compared to that in normal children. Furthermore, unusual refractive status can complicate the developmental paths of children with ASD by affecting their ability to interact with educational materials and social settings, highlighting the necessity for systematic vision screening and personalized visual interventions for this vulnerable group.

In our ophthalmology clinic, we have observed that some children with neurodevelopmental disorders or growth retardation exhibit delayed or abnormal ocular development,[21] such as structural features like a shortened axial length and a shallow anterior chamber. We hypothesize that, in addition to refractive errors, the visual system structure of children with ASD—a disorder involving extensive neurodevelopmental abnormalities—may also undergo corresponding changes. Unlike refractive errors, the characteristics of ocular biometric parameters (eg, axial length (AL), anterior chamber depth (ACD), and lens thickness (LT)) in ASD children remain inadequately studied, with limited existing literature and inconsistent conclusions. This study aims to systematically investigate whether these biometric parameters differ between ASD children and the control group. A systematic evaluation of ocular biometric parameters in ASD children will not only enhance our understanding of their visual development characteristics but may also provide new insights into exploring biological markers for ASD.

Current research in this area has two primary limitations: firstly, traditional ASD studies predominantly depend on behavioral assessments and lack quantitative analysis of ocular bioparameters; secondly, existing research on refractive development mainly targets typically developing populations, overlooking ASD-specific refractive paths and ocular biometry. Importantly, anomalies in refractive parameters can degrade the quality of visual input, potentially worsening social avoidance behaviors in children with ASD due to sensorimotor integration processes.[22,23] The underlying pathological mechanism of this negative cycle is not yet understood. Hence, a systematic examination of refractive development traits in children with ASD has significant clinical value in ophthalmology, aiding in the development of targeted screening strategies and introducing a new research framework for understanding neurodevelopmental issues in ASD.

In recent years, machine learning algorithms have been successfully applied to tackle complex issues in the field of ophthalmic refractive surgery, such as predicting myopia progression[24] and optimizing refractive surgery outcomes.[25] These studies indicate that machine learning has unique advantages in processing multidimensional ocular biological parameters. This study aimed to explore the refractive development and ocular biometric characteristics of children with ASD and quantitatively measure key parameters like AL and K1. Machine learning algorithms were used to create a model linking refractive parameters with ASD clinical features, addressing the following questions: (1) Do children with ASD have a refractive development pattern that differs from that of normal developing children? (2) Can specific refractive anomalies (eg, high astigmatism, anisometropia) be used as biomarkers for the early identification of ASD? The study's outcomes are expected to drive significant clinical advancements, leading to the creation of ASD visual screening protocols and enhancing visual perception quality through refractive correction. In addition, the identification of specific biomarkers may improve ASD screening.

Materials and Methods

Participants

The study included 95 children diagnosed with ASD, aged 4 to 12 years, recruited from 14 special education centers in Handan between March and June 2024. Additionally, 96 healthy children who were recruited from the same community

in the region and matched in age and gender were included. All participants underwent a thorough ocular examination following the Declaration of Helsinki guidelines, with ethical approval from Tianjin Eye Hospital (No. 022009). This study was registered as a clinical trial (Clinical Trials.gov ID NCT06122519). The inclusion criteria were children aged 4–12 years with a diagnosis of ASD for > 1 year, normal intraocular pressure (IOP), and no significant ocular pathology, and who could cooperate with the examination. Exclusion criteria included a history of congenital cataracts, corneal diseases, or ocular surgery. Written informed consent was obtained from the participants' family members or legal guardians.

Examination

The children with ASD and healthy controls underwent identical examinations. (1) To exclude organic ocular diseases, the anterior segment was examined using a handheld slit-lamp biomicroscope, and the fundus condition was assessed by handheld fundus photography. (2) Refraction examination included uncorrected distance vision, UCDVA (digital or HOTV chart), and equivalent spherical diopter. Given the common traits of gaze avoidance and cooperation difficulty in children with ASD, we utilized the Spot Vision screener (Welch Allyn VS100) in combination with retinoscopy for comprehensive refraction assessment. All refraction examinations were independently conducted by two seasoned optometrists. The results from the Spot Vision screener and retinoscopy were cross - validated to ensure consistency in data collection. (3) Ocular biometric parameters, including axial length (AL), keratometry (K1, K2), anterior chamber depth (ACD), and corneal astigmatism (AST), axial length to corneal radius ratio (AL/CR), Central Corneal Thickness (CCT), White-to-White distance (WTW), lens thickness (LT), and vitreous thickness (VT), were measured using the SW-9000 (Suoer, Tianjin, China), which is based on Optical Low-Coherence (OLCR) technology. The mean of 5 acceptable measurements was used for analysis. (4) All examiners were experienced physicians and senior optometrists specializing in pediatric ophthalmology. Children with ASD exhibited less cooperation during the examination process, requiring examiners and their special education teachers to demonstrate increased patience. The detection personnel underwent professional training and passed assessments before participating in data collection, strictly following operational standards. (5) Instruments were calibrated with a model eye before measurements, and data on refractive error and ocular biological parameters were collected and analyzed. (6) Refractive status was recorded as spherical equivalent (SE), calculated as the sphere plus half of the cylinder.[26] The characteristics of emmetropia are SE between −0.50DS and +0.50DS. Astigmatism is characterized by CYL greater than 0.50DC, greater than 2.00DC indicates high astigmatism.[27,28]

Statistical Analysis

SPSS version 27 was used for data analysis. For normally distributed data, means and standard deviations were reported, and independent samples *t*-tests were performed. For non-normally distributed data, the median and interquartile range were presented, and the rank-sum test was used. Logistic regression analysis was conducted for multivariate analysis, with a significance level of $\alpha = 0.05$.

Random forest, support vector machine models, KNN, decision tree, and naive Bayes models were used to identify statistically significant ASD risk predictors. Evaluation results of the different models were compared, and a reasonable model for machine learning was selected to discover reliable ASD risk prediction factors.

Results

The Demographic Distribution

The study included 95 children with ASD (70.5% male, 29.5% female) and 96 controls (68.8% male, 31.2% female), with median ages of 8 and 7 years. There were no statistically significant differences between the two groups in terms of age or gender ($z = -0.16$, $p = 0.873 > 0.05$ for age; $z = -0.588$, $p = 0.557 > 0.05$ for gender) (Figure 1 and Supplementary Table 1).

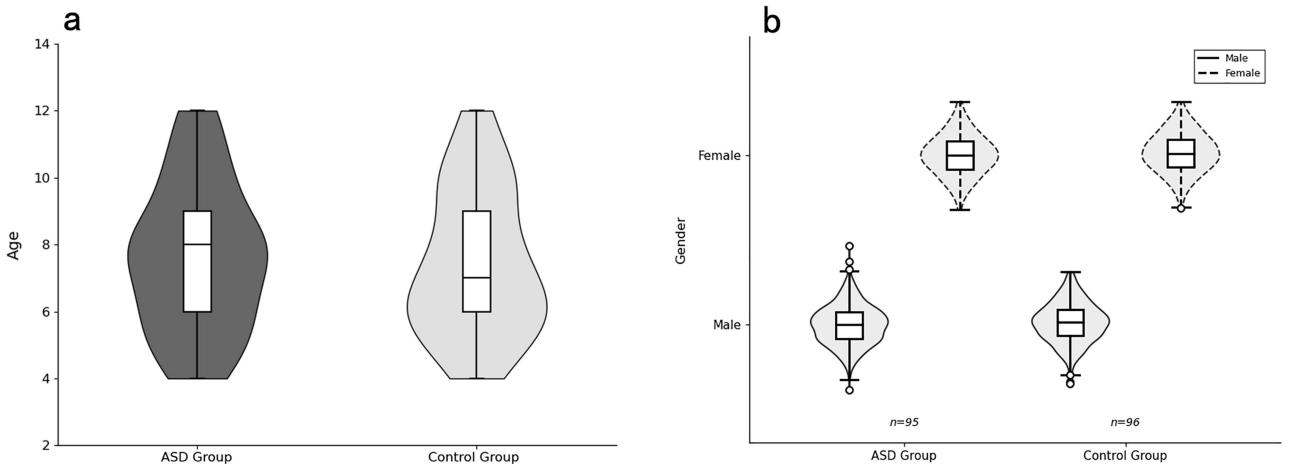

Figure 1 Demographic distribution of the ASD group and the control group. (**a**) The violin plot displays two sets of age data. (**b**) The bar chart displays two sets of gender data.

Alteration in Refractive Condition

Statistical analysis was performed to assess the differences in refractive status between the control group and the ASD group. The findings revealed significant differences in spherical power (SPH) between the groups (SPH: ASD 0.25 ±1.10 DS vs control −0.25 ±2.10 DS for each group, $z = -4.936$, $p < 0.01$), in cylinder (CYL: ASD −0.75 ±1.50DC vs control −0.50 ±0.50 DC, $z = -2.744$, $p = 0.006 < 0.01$), and in spherical equivalent (SE: ASD 0.00 ±1.30 DS vs control −0.50 ±1.80 DS, $z = -3.400$, $p = 0.001 < 0.01$). Children with ASD demonstrated a greater propensity for hyperopia and higher astigmatism. To depict the differences in refractive status between the two groups more clearly, violin plots of SPH, CYL, and SE are shown in Figure 2a–c (Supplementary Table 2).

Changes in Ocular Biological Parameters in Patients with ASD

Comparative analysis of ocular biometric parameters between the ASD group and the control group revealed statistically significant differences in ACD ($t = 2.201$, $p = 0.029 < 0.05$) and VT ($t = 2.056$, $p = 0.041 < 0.05$). The ASD group exhibited a lower ACD and VT than those of the control group (all $p < 0.05$). No statistically significant differences were found for the other indicators (Table 1).

Correlation Between SE and Ocular Biometric Parameters in the ASD Group

Correlation analysis of refractive status and ocular biometric parameters in children with ASD revealed a notable negative correlation between SE and AL ($r = -0.377$, $p < 0.01$), and between SE and AL/CR ($r = -0.359$, $p < 0.01$). Additionally, in the ASD group, relationship between SE and ocular biometric measurements was significant: we observed a negative correlation between SE and ACD ($r = -0.237$, $p < 0.05$), a significant positive correlation between

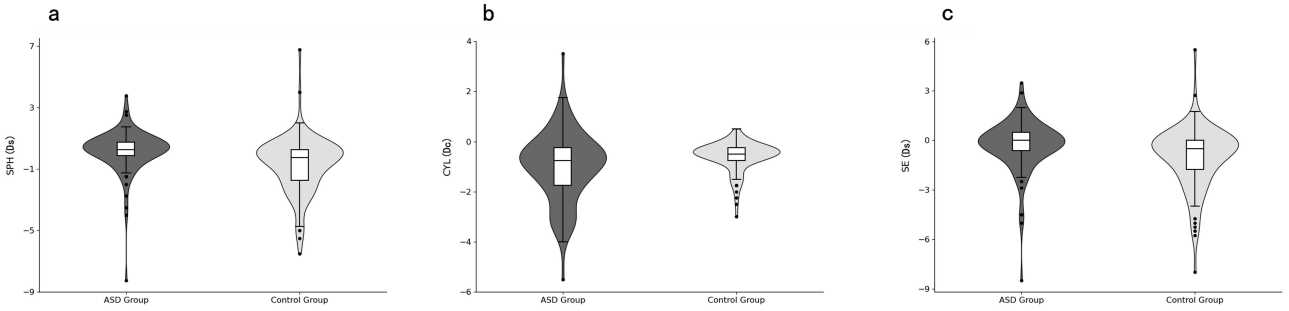

Figure 2 Refractive status of the ASD group and the control group. (**a**) The violin plot displays two sets of SPH data. (**b**) The violin plot displays two sets of CYL data. (**c**) The violin plot displays two sets of SE data.

Table 1 Ocular Biological Parameters of the ASD Group and the Control Group

	Group M ($\bar{x} \pm s$)		***t* value**	***p* value**
	Control Group (n = 96)	**ASD Group (n = 95)**		
K2	44.04 ±1.43	44.13 ±1.89	−0.361	0.719
ACD	3.03 ±0.34	2.93 ±0.26	2.201	**0.029***
VT	16.23 ±1.30	15.88 ±0.98	2.056	**0.041***
	Group M (*M*±*Q*)		***Z* value**	***p* value**
	Control Group (n = 96)	**ASD Group (n = 95)**		
AL	23.19 ±1.70	22.94 ±1.30	−1.683	0.092
K1	42.88 ±1.70	42.59 ±1.60	−0.815	0.415
AST	−1.14 ±0.70	−1.22 ±1.20	−0.964	0.335
AL/CR	2.94 ±0.20	2.94 ±0.10	−1.648	0.099
CCT	538.0 ±36.0	535.5 ±43.8	−0.459	0.646
WTW	11.98 ±0.50	11.97 ±0.5	−1.165	0.244
LT	3.50 ±0.40	3.63 ±0.30	−1.629	0.103

Notes: *p<0.05: Values in bold indicate statistical significance at p<0.05. Between the ASD group and the control group revealed statistically significant differences in ACD (t = 2.201, p = 0.029 <0.05) and VT (t = 2.056, p = 0.041 <0.05). K2, ACD, VT are normally distributed data, and parametric tests are used for statistical analysis. AL, K1, AST, AL/CR, CCT, WTW, LT are non-normally distributed data, and non-parametric tests are used for statistical analysis.

SE and LT (r = 0.266, p < 0.05), and a significant negative correlation between SE and VT (r = −0.419, p < 0.01); however, no significant correlation of SE with K1, K2, AST, WTW, and CCT was observed (all p-values > 0.05) (Table 2).

Binary Logistic Regression Analysis of Refractive and Biometric Factors

Binary logistic regression analysis was performed on the refractive status and ocular biological parameters of both the ASD and control groups. The findings indicated that SE (OR = 1.732, 95% CI: 1.245 ~ 2.410), CYL (OR = 0.504, 95% CI: 0.346 ~ 0.734), AL/CR (OR = 84.505, 95% CI: 1.188 ~ 6012.705), and ACD (OR = 0.201, 95% CI: 0.043 ~ 0.930) were significantly associated with ASD (all p values < 0.05). Compared with the control group, children in the ASD group showed a greater likelihood of hyperopia, higher astigmatism diopter values, lower axial length-to-corneal radius ratios, and shallower anterior chamber depths. (The results of the binary logistic regression analysis were shown as Table 3).

When plotting ROC curves for SE, CYL, AL/CR, and ACD (with specificity on the x-axis and sensitivity on the y-axis), the combined diagnostic approach proved more significant than individual factors in predicting ASD risk, with an AUC value of 0.741 (95% CI: 66.94% ~ 81.19%). This implies that AL/CR, ACD, and refractive status (SE, CYL) could serve as potential predictors for ASD, and a combined assessment can identify children with high sensitivity and specificity for ASD. These children should undergo assessment using scales for diagnostic confirmation. Early detection of these ocular biological parameters may enable more proactive clinical interventions, thereby improving the visual and developmental outcomes for children at high risk or already diagnosed with ASD. (The ROC curve is shown in Figure 3a, The ROC AUC summary is shown in Supplementary Table 3).

Table 2 Correlation Analysis Between the SE and Ocular Biological Parameters in the ASD Group

	r value	*p* value	n
AL	**−0.377****	**0.000****	94
K1	0.028	0.786	94
K2	−0.071	0.496	94
AST	0.196	0.058	94
AL/CR	**−0.359****	**0.000****	92
ACD	**−0.237***	**0.025***	90
CCT	0.183	0.083	90
WTW	−0.003	0.976	82
LT	**0.266***	**0.011***	90
VT	**−0.419****	**0.000****	90

Notes: *p<0.05: Values in bold indicate statistical significance at p<0.05, **p<0.01: Values in bold indicate statistical significance at p<0.01. In the ASD group, SE was significantly negatively correlated with AL ($r = -0.377$, $p < 0.01$) and AL/CR ($r = -0.359$, $p < 0.01$); negatively correlated with ACD ($r = -0.237$, $p < 0.05$); positively correlated with LT ($r = 0.266$, $p < 0.05$); and negative correlation with VT ($r = -0.419$, $p < 0.01$). Bold text indicates statistical significance ($p < 0.05$).

Table 3 Binary Logistic Regression Analysis Results

Item	β value	SE	z value	Wald $\chi 2$	p value	OR value	OR value 95% CI
CYL	−0.686	0.192	−3.571	12.755	**0.000****	0.504	0.346 ~ 0.734
SE	0.549	0.168	3.26	10.625	**0.001****	1.732	1.245 ~ 2.410
AL/CR	4.437	2.176	2.039	4.158	**0.041***	84.505	1.188 ~ 6012.705
ACD	−1.604	0.782	−2.053	4.214	**0.040***	0.201	0.043 ~ 0.930
Intercept	−8.63	5.333	−1.618	2.619	0.106	0	0.000 ~ 6.188

Notes: *p<0.05: Values in bold indicate statistical significance at p<0.05, **p<0.01: Values in bold indicate statistical significance at p<0.01. Dependent variable: group (ASD vs control). Model fit indices: McFadden R2 = 0.106; Cox & Snell R2 = 0.137; Nagelkerke R2 = 0.183. Bold indicates statistical significance.

Abbreviations: SE, spherical equivalent; CYL, cylindrical diopter; AL/CR, axial length-to-corneal radius ratio; ACD, anterior chamber depth; OR, odds ratio; CI, confidence interval.

Machine Learning Model Evaluation for ASD Correlation Analysis

Random forest, support vector machine, KNN, decision tree, and naive Bayes models were used to identify statistically significant ASD risk predictors. The evaluation effects of different models were compared, and a reasonable model for machine learning was selected. After evaluating the effectiveness of various machine learning models, the random forest model emerged as the most stable This model was developed to identify predictive factors for ASD, specifically focusing on SE, CYL, AL/CR, and ACD. The feature weights revealed the significance of each factor's contribution to the model, collectively summing up to 1. The findings highlighted that SE and ACD accounted for 25.50% and 25.28% of the

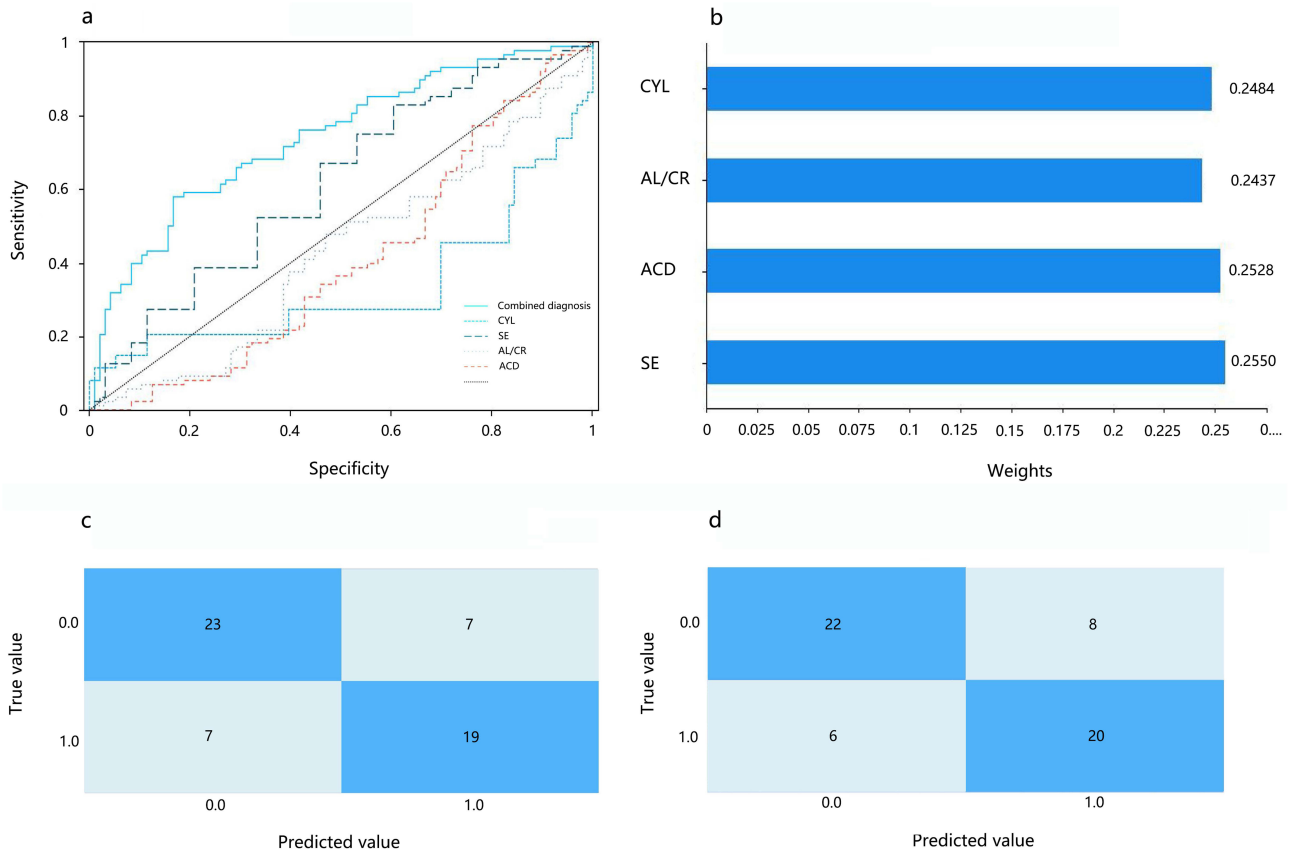

Figure 3 Machine Learning Results Analysis. (**a**) Plotting the ROC curves for SE, CYL, AL/CR, ACD. (**b**) Developing a Random Forest Model to identify predictive factors of ASD. The weight results show that SE and ACD are significant predictors, with respective weights of 25.50% and 25.28% (where the x-axis represents the weight, contribution and the y-axis represents the predictive factors). (**c**) Confusion Matrix for Random Forest Test Set Results. (**d**) Confusion Matrix for Support Vector Machine Test Set Results.

model, respectively, underscoring their crucial role in the model's development. This suggests that SE and ACD could be particularly valuable for early screening and diagnosis of ASD. (The results of the machine learning model are shown in Figure 3b–d, The effectiveness of the machine learning model evaluation is shown in Supplementary Table 4. The results of the Random Forest model weight analysis are presented in Supplementary Table 5).

Discussion

This study provides an in-depth examination of refractive and ocular biometric characteristics in children with ASD. The findings revealed that the ASD group had a higher prevalence of hyperopia, while the control group was more prone to myopia, with astigmatism being more prominent in the ASD group. Both Scharre[13] and Ikeda[29] identified that 40% ~44% of children with ASD had refractive errors, with astigmatism being17.6%, followed by strabismus and amblyopia. Similar result was shown by Khanna.[11] These foundational studies consistently support our finding that children with ASD experience varying levels of refractive errors and astigmatism. However, Wang J et al[30] reported normal refractive status in children with ASD, potentially due to variations in sample size, research methods, and selection criteria.

From birth to adolescence, refractive status continues to change as the eye develops.[31,32] Research by Bikbov et al indicates that preschool children (ages 0–6) are primarily hyperopia, with the proportion of hyperopia decreasing and myopia increasing as children age.[33–35] Children with ASD tend to have higher rates of hyperopia and lower rates of myopia, which may be related to the generally reduced time ASD children spend on reading and close writing tasks. Meanwhile, the refractive status of patients with ASD might be linked to neurodevelopmental abnormalities, suggesting that refractive status could serve as a potential biological marker for ASD. A high degree of hyperopia or a low degree of

https://doi.org/10.2147/IJGM.S572336

myopia may be related to the unique way in which patients with ASD process visual information, providing clues for further research into the visual perception mechanisms in ASD.

This study revealed significant correlations between SE and ocular biometric parameters in children with ASD: negative associations with AL, AL/CR, ACD, and VT (all $p<0.05$), but a positive correlation with LT ($p<0.05$). Notably, ASD children exhibited lower ACD and VT values compared to controls ($p<0.05$), while other parameters showed no intergroup differences ($p>0.05$). These findings suggest that ASD children with shorten AL, reduced AL/CR, shallowed ACD, elongated LT, or decreased VT are predisposed to hyperopic shifts. Currently, the predictive factors for ASD primarily include various psychological and behavioral characteristics, with ocular predictors focusing mainly on eye movements and visual attention.[36,37] Research on ocular biometric parameters is relatively limited. This study conducted a multifactorial analysis of the refractive status and ocular biometric parameters in both ASD group and control group. The results indicated that SE, CYL, AL/CR, and ACD were associated with the risk of ASD onset. Compared with that by he control group, children with ASD showed a stronger tendency toward hyperopia, higher astigmatism, lower axial ratios, and shallower anterior chamber depth. From a mechanistic perspective, the hyperopia tendency and shallower ACD observed in children with ASD may reflect structural delays or abnormalities during ocular development. Previous studies have predominantly focused on refractive abnormalities in ASD populations, while systematic evaluations of ocular biometric parameters such as AL, ACD, and LT remain relatively scarce. This study is the first to demonstrate in the northern population of China that children with ASD exhibit a shallower ACD. SE shows negative correlations with AL, AL/CR, ACD, and VT, as well as positive correlations with LT. These findings suggest potential coordinated developmental disorders in the anterior and posterior segments of the eye. It is important to note that these findings represent associations observed in this specific sample and their qualification as distinct traits of ASD relative to the general population requires confirmation through larger, multi-center studies.

By plotting the ROC curves for SE, CYL, AL/CR, and ACD, we found that jointly using these biological parameters for prediction offers greater diagnostic significance than using a single factor. This study indicates that AL/CR, ACD, and refractive status (SE, CYL) are strong associated factors for ASD. The combined assessment of these parameters can significantly enhance the sensitivity and specificity of predicting ASD risk. Therefore, evaluating ocular biometric parameters can help identify children at higher risk for ASD. These children should undergo further scale analysis and clinical symptom evaluation, and when collaboration is limited, early identification of these ocular parameters may provide more opportunities for clinical intervention, thereby improving visual and developmental outcomes for children at risk or already diagnosed with ASD. The machine learning model evaluation demonstrated the superior stability of the random forest model in identifying ASD predictors. This model identified four key features: SE, CYL, AL/CR, and ACD. Feature importance analysis revealed SE (25.5%) and ACD (25.3%) were the dominant contributors, collectively accounting for more than 50% of the model's predictive power. These findings provide a new perspective for understanding the visual developmental characteristics of children with ASD, and also offer preliminary evidence for exploring the potential link between neurodevelopmental disorders and ocular structures.

As a cross-sectional study, this research achieves dual innovations in the methodology of ASD studies: firstly, it breaks through the traditional behavioral and neurological assessment paradigms by systematically integrating ocular biometry with refractive parameter analysis for the first time, providing a new approach to identifying neurodevelopmental biomarkers; secondly, it innovatively introduces machine learning (random forest model) to quantitatively evaluate the predictive value of key ocular parameters. The study was conducted on ASD children aged 4–12 in Handan, China, and identified for the first time four ocular parameters significantly associated with ASD status: SE, CYL, AL/CR, and ACD, among which SE and ACD contributed the most in the model. The core contribution of this study lies in objectively revealing the differential structural characteristics of the anterior segment of the eye (ACD, AL) in ASD children for the first time in a regional population. These structural parameters are minimally influenced by regulatory factors and exhibit high measurement stability, constituting the most reliable findings in the study and providing a new perspective for "visual-neurodevelopmental" collaborative research to understand the neurodevelopmental mechanisms of ASD. Although the absence of cycloplegic refraction may affect the accurate interpretation of refractive results, the identified structural differences still hold significant implications, offering preliminary evidence for incorporating ocular biometry into systematic health assessments of ASD children in the future. The strategy of

integrating multiple parameters based on machine learning is expected to promote the establishment of an active monitoring framework for high-risk children, providing new insights for improving visual and overall developmental outcomes of ASD children through early identification and intervention.

This study also has several limitations. The most significant limitation lies in the absence of cycloplegic refraction due to cooperative barriers and environmental constraints, which may underestimate the degree of hyperopia in both groups, particularly in the ASD group, thereby reducing the difference between the two groups. Additionally, the measured astigmatism differences may be confounded by unknown variations in accommodation tension or accommodation ability between children with ASD and typically developing children. Such accommodation factors may be related to ASD-specific sensory processing abnormalities and anxiety during examination.[22] Therefore, the interpretation of refractive examination results should be approached with extreme caution, as the current findings may incorporate contributions from structural differences and functional accommodation artifacts. Future studies should further clarify these findings by integrating cycloplegic refraction and accommodation function measurements. Although the same testing protocol was used in both groups to reduce operational bias, the severity of hyperopia and its clinical significance still require validation through prospective, large-sample cycloplegic studies. Secondly, the sample was concentrated in Handan, a region with relatively better economic and medical conditions, and its representativeness may favor high-functioning ASD subgroups, potentially introducing selection bias. Furthermore, the conclusions of this study primarily apply to ASD children who can complete standardized ophthalmic examinations. The sample may more likely represent behaviorally cooperative, high-functioning ASD subgroups, and thus the findings may not generalize to the entire ASD spectrum, especially individuals with severe behavioral challenges or lower functional levels. The external validity of the study conclusions needs to be validated in future multicenter, larger, and more representative studies. Thirdly, although this study identified significant structural differences such as shallower ACD in the ASD group, which are not influenced by confounding factors and demonstrate high measurement stability, constituting the most robust findings of this research, it must be acknowledged that the development of ocular biometric parameters is influenced by multiple factors. The current cross-sectional data cannot establish a causal relationship between these differences and ASD, and their specificity and generalizability require further validation through longitudinal studies. Finally, the machine learning models (eg, random forests) employed in this study are limited by sample size, and their generalization ability and stability need to be further validated in prospective large-sample data. Therefore, the model results should be regarded as exploratory analyses aimed at suggesting potential important features (eg, SE and ACD) rather than for clinical diagnosis or prediction. The most robust statistical conclusions in this study still originate from traditional logistic regression analysis, and all analyses can only reveal correlations between variables, not infer causal relationships.

Future research should continue to deepen in the following aspects: 1. Conduct multicenter, large-sample prospective cohorts, combining optometric examination with accommodative function assessment in strabismus, and differentiate functional and structural influencing factors by integrating ocular biometric data to enhance the reliability of biological explanations and improve the generalizability of research findings; 2. Adopt longitudinal designs to explore the temporal sequence relationship between ocular parameter abnormalities and the emergence of core ASD symptoms, providing temporal evidence for early identification; 3. Further integrate genetic, behavioral, and environmental factors, utilizing deep learning algorithms to analyze the complex relationships between multidimensional indicators and ASD subtypes; 4. Explore the long-term effects of refractive correction and visual interventions on improving visual function and neurobehavioral development in ASD children, providing a basis for developing personalized visual rehabilitation plans.

Conclusion

This study systematically evaluated the refractive status and ocular biometric parameters of children with ASD, revealing differential manifestations in hyperopia, astigmatism, and anterior chamber depth. These findings suggest that multi-parameter combined assessment may have potential as an auxiliary tool for ASD identification. Despite the aforementioned limitations, these discoveries provide a novel visual biology perspective for interdisciplinary ASD research and lay the foundation for subsequent mechanistic exploration and clinical interventions.

Data Sharing Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Ethics Approval and Consent to Participate

The study was approved by the Ethics Committee of Medicine, Tianjin Eye Hospital (No. 022009). All participants signed informed consent in accordance with the Declaration of Helsinki.

Acknowledgments

The authors are grateful to the volunteers who actively participated in the research, the staff behind the research, and the participants family members for their strong support.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

This research was supported by Tianjin Metrology Science and Technology Project (2024TJMT007; No. 2024TJMT032), Tianjin Health Research Project (No. TJWJ2022XK037), Hebei TCM Administration Bureau Research Projects (T2025028), Open Fund of the Vision Science Research Institute, Nankai University (NKSGZ202302, QS 20241144), Open Fund of the Ophthalmology Research Institute, Nankai University (NKYKK202308, NKYKD202202), The 3rd Tianjin Talent Development Program and the High-level Talents Program in TJHS and Tianjin key Medical Specialty Construction Project, Tianjin Key Medical Discipline (Specialty) Construction Project (No. TJYXZDXK-016A).

Disclosure

The authors report no conflicts of interest in this work.

References

1. Ashmawi NS, Hammoda MA. Early prediction and evaluation of risk of autism spectrum disorders. *Cureus*. 2022;14(3):e23465. doi:10.7759/cureus.23465
2. Wang L, Wang B, Wu C, Wang J, Sun M. Autism spectrum disorder: neurodevelopmental risk factors, biological mechanism, and precision therapy. *Int J Mol Sci*. 2023;24(3):1819. doi:10.3390/ijms24031819
3. Zhou H, Xu X, Yan W, et al. Prevalence of autism spectrum disorder in China: a nationwide multi-center population-based study among children aged 6 to 12 years. *Neurosci Bull*. 2020;36(9):961–971. doi:10.1007/s12264-020-00530-6
4. Maenner MJ, Shaw KA, Bakian AV, et al. Prevalence and characteristics of autism spectrum disorder among children aged 8 years - autism and developmental disabilities monitoring network, 11 sites, United States, 2018. *MMWR Surveill Summ*. 2021;70(11):1–16. doi:10.15585/mmwr.ss7011a1
5. Maenner MJ, Warren Z, Williams AR, et al. Prevalence and characteristics of autism spectrum disorder among children aged 8 years - Autism and developmental disabilities monitoring network, 11 sites, United States, 2020. *MMWR Surveill Summ*. 2023;72(2):1–14. doi:10.15585/mmwr.ss7202a1
6. Yang T, Chen L, Dai Y, et al. Vitamin A status is more commonly associated with symptoms and neurodevelopment in boys with autism spectrum disorders-a multicenter study in China. *Front Nutr*. 2022;9:851980. doi:10.3389/fnut.2022.851980
7. Sun X, Allison C, Wei L, et al. Autism prevalence in China is comparable to Western prevalence. *Mol Autism*. 2019;10:7. doi:10.1186/s13229-018-0246-0
8. Takahashi N, Harada T, Nishimura T, et al. Association of genetic risks with autism spectrum disorder and early neurodevelopmental delays among children without intellectual disability. *JAMA Network Open*. 2020;3(2):e1921644. doi:10.1001/jamanetworkopen.2019.21644
9. Lamanna J, Meldolesi J. Autism spectrum disorder: brain areas involved, neurobiological mechanisms, diagnoses and therapies. *Int J Mol Sci*. 2024;25(4):2423. doi:10.3390/ijms25042423
10. Kim JY, Son MJ, Son CY, et al. Environmental risk factors and biomarkers for autism spectrum disorder: an umbrella review of the evidence. *Lancet Psychiatry*. 2019;6(7):590–600. doi:10.1016/S2215-0366(19)30181-6
11. Khanna RK, Kovarski K, Arsene S, et al. Ophthalmological findings in children with autism spectrum disorder. *Graefes Arch Clin Exp Ophthalmol*. 2020;258(4):909–916. doi:10.1007/s00417-019-04594-7

12. Bogdashina O. *Sensory Perceptual Issues in Autism and Asperger Syndrome: Different Sensory Experiences, Different Perceptual Worlds*. London, UK: Jessica Kingsley Publishers; 2003.
13. Scharre JE, Creedon MP. Assessment of visual function in autistic children. *Optom Vis Sci*. 1992;69(6):433–439. doi:10.1097/00006324-199206000-00004
14. Black K, McCarus C, Collins ML, Jensen A. Ocular manifestations of autism in ophthalmology. *Strabismus*. 2013;21(2):98–102. doi:10.3109/09273972.2013.786733
15. Ezegwui IR, Lawrence L, Aghaji AE, et al. Refractive errors in children with autism in a developing country. *Niger J Clin Pract*. 2014;17(4):467–470. doi:10.4103/1119-3077.134042
16. Singman E, Matta N, Fairward A, et al. Evaluation of plusoptiX photoscreening during examinations of children with autism. *Strabismus*. 2013;21(2):103–105. doi:10.3109/09273972.2013.786736
17. Anketell PM, Saunders KJ, Gallagher SM, et al. Brief report: vision in children with autism spectrum disorder: what should clinicians expect. *J Autism Dev Disord*. 2015;45(9):3041–3047. doi:10.1007/s10803-015-2431-8
18. Kabatas EU, Ozer PA, Ertugrul GT, et al. Initial ophthalmic findings in turkish children with autism spectrum disorder. *J Autism Dev Disord*. 2015;45(8):2578–2581. doi:10.1007/s10803-015-2428-3
19. Tao J, Hao R, Guo YT, et al. Analysis of visual function characteristics in children with autism spectrum disorders and intellectual disabilities. *Chin J Ophthalmol*. 2022;58(12):1051–1057. doi:10.3760/cma.j.cn112142-20220207-00046
20. Wu CS, Tsai TH, Chen WL, et al. Ophthalmologic diagnoses in youths with autism spectrum disorder: prevalence and clinical correlates. *Autism Res*. 2023;16(10):2008–2020. doi:10.1002/aur.3019
21. Parentin F, Tonini G, Perissutti P. Refractive evaluation in children with growth defect[J]. *Curr Eye Res*. 2004;28(1):11–15. doi:10.1076/ceyr.28.1.11.23491
22. Bakroon A, Lakshminarayanan V. Visual function in autism spectrum disorders: a critical review. *Clin Exp Optom*. 2016;99(4):297–308. doi:10.1111/cxo.12383
23. Simmons DR, Robertson AE, McKay LS, et al. Vision in autism spectrum disorders. *Vision Res*. 2009;49(22):2705–2739. doi:10.1016/j.visres.2009.08.005
24. Barraza-Bernal MJ, Ohlendorf A, Sanz Diez P, et al. Prediction of refractive error and its progression: a machine learning-based algorithm. *BMJ Open Ophthalmol*. 2023;8(1):e001298. doi:10.1136/bmjophth-2023-001298
25. Shi T. Machine learning predictive model based on the corneal biomechanics of clinical data. *Photodiagnosis Photodyn Ther*. 2025;56:105262. doi:10.1016/j.pdpdt.2025.105262
26. Flitcroft DI, He M, Jonas JB, et al. IMI - defining and classifying myopia: a proposed set of standards for clinical and epidemiologic studies. *Invest Ophthalmol Vis Sci*. 2019;60(3):M20–M30. doi:10.1167/iovs.18-25957
27. Wolffsohn JS, Flitcroft DI, Gifford KL, et al. IMI - myopia control reports overview and introduction. *Invest Ophthalmol Vis Sci*. 2019;60(3):M1–M19. doi:10.1167/iovs.18-25980
28. Read SA, Collins MJ, Carney LG. A review of astigmatism and its possible genesis. *Clin Exp Optom*. 2007;90(1):5–19. doi:10.1111/j.1444-0938.2007.00112.x
29. Ikeda J, Davitt BV, Ultmann M, et al. Brief report: incidence of ophthalmologic disorders in children with autism. *J Autism Dev Disord*. 2013;43(6):1447–1451. doi:10.1007/s10803-012-1475-2
30. Wang J, Ding G, Li Y, et al. Refractive status and amblyopia risk factors in Chinese children with autism spectrum disorder. *J Autism Dev Disord*. 2018;48(5):1530–1536. doi:10.1007/s10803-017-3387-7
31. Singh SE, Ostrin LA, Kerber KL, et al. Refractive Error and Axial Length (REAL) Study: Feasibility of a population study in the United States. *Optom Vis Sci*. 2025;102(5):280–288. doi:10.1097/OPX.0000000000002258
32. Mutti DO, Sinnott LT, Lynn Mitchell G, et al. Ocular Component Development during Infancy and Early Childhood. *Optom Vis Sci*. 2018;95(11):976–985. doi:10.1097/OPX.0000000000001296
33. Mu J, Zhang Z, Wu X, et al. Refraction and ocular biometric parameters in 3-to 6-year-old preschool children : a large-scale population-based study in Chengdu, China. *BMC Ophthalmol*. 2024, May 6;24(1):207. doi:10.1186/s12886-024-03467-w
34. Bikbov MM, Kazakbaeva GM, Fakhretdinova AA, et al. Associations between axial length, corneal refractive power and lens thickness in children and adolescents: the ural children eye study. *Acta Ophthalmol*. 2024;102(1):94–104. doi:10.1111/aos.15692
35. Tang T, Zhao H, Liu D, et al. Axial length to corneal radius of curvature ratio and refractive error in Chinese preschoolers aged 4-6 years: a retrospective cross-sectional study. *BMJ Open*. 2023;13(12):e075115. doi:10.1136/bmjopen-2023-075115
36. Van der Geest JN, Kemner C, Camfferman G, et al. Eye movements, visual attention, and autism: a saccadic reaction time study using the gap and overlap paradigm. *Biol Psychiatry*. 2001;50(8):614–619. doi:10.1016/S0006-3223(01)01070-8
37. Jaradat AS, Wedyan M, Alomari S, et al. Using machine learning to diagnose autism based on eye tracking technology. *Diagnostics*. 2024;15(1):66. doi:10.3390/diagnostics15010066