Clinical Ophthalmology

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ORIGINAL RESEARCH

Success Rate of Swept-Source Optical Coherence Tomography Biometry of Eyes of Elementary School Students

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Purpose: To determine the success rate of swept-source optical coherence tomography (SS-OCT) biometry (OA-2000) in elementary school students.

Methods: This was a prospective observational longitudinal study of 115 right eyes of elementary school students who were 8- to 9-years-old at the initial examination. Biometric measurements of the eyes were performed annually for three years, viz., during the third, fourth, and fifth grades. The success rates of obtaining data from optical biometric measurements of the axial length (AL), central corneal thickness (CCT), anterior chamber depth (ACD), lens thickness (LT), pupillary diameter (PD), corneal diameter (CD), and corneal curvature (CC) were determined.

Results: The AL, CCT, and CC could be measured in all images at the three measurement times in all subjects. The success rate of the measurements of the ACD was 92.2% in the third grade and 100% in the fourth and fifth grade. The LT was successfully measured in 88.7% in the third grade, 99.1% in the fourth grade, and 100% in the fifth grade. The PD was successfully measured in 100% of the third grade, 96.0% of the fourth grade, and 100% in the fifth grade. The CD was successfully measured in 84.3% in the third grade, 66% in the fourth grade, and 100% in the fifth grade.

Conclusion: SS-OCT can obtain accurate measures of all ocular parameters in the primary school students with high success rates. However, care should be taken especially in analyzing the ACD, LT, PD, and CD because errors can occur in some cases.

Keywords: swept source optical coherence tomography, success rate, elementary school children

Introduction

Myopia is a common eye disease especially in Asians, and high myopia of > −6 diopters (D) can lead to pathological myopia which is a major cause of blindness worldwide.[1,2] The prevalence of myopia is increasing, and the socioeconomic impact on individuals and society is substantial.[3–6] Myopia is a serious problem in Asian countries[7–9] because of the increasing incidence and decreasing age of the onset.[3,4] In addition, individuals with myopia have a significantly higher incidence of glaucomatous optic neuropathy, and those with high myopia have a higher risk of glaucoma than those with low to moderate myopia.[9] Thus, it is important to determine the myopic changes during the growth phase of young children.

Because an elongation of the AL plays an important role in the development of school age myopia,[6,10,11] a reliable measurement of the AL is necessary when monitoring the progression of myopia in school age children.[12–15] However, the refractive error is also determined by the refractive power of the cornea and crystalline lens, and the anterior chamber depth (ACD).[10,11] Importantly, these ocular parameters are known to change in school age children. When research is performed on the cause of refractive errors, it is difficult to draw definitive conclusions because of the complex interplay

Received: 28 June 2022
Accepted: 11 October 2022
Published: 1 November 2022

of the factors that affect these three parameters. Therefore, accurate measurements of the ocular biometrics are important in studies on the development of school age children.

Swept-source optical coherence tomographic (SS-OCT) devices can obtain values of the AL, central corneal thickness (CCT), corneal diameter (CD), corneal curvature (CC), anterior chamber depth (ACD), lens thickness (LT), and pupillary diameter (PD) in about 10 seconds.[16–21] Several studies have shown that these ocular biometric parameters, viz., the PD, CC, LT, and ACD, can affect the axial elongation in children.[22–25] There are other studies that determined the repeatability and agreement of the values obtained by the SS-OCT optical biometric devices in adults[16–19] and children.[20,21] However, to the best of our knowledge, there is no report on the success rate of obtaining the ocular biometric parameters in school age children.

Thus, the purpose of this study was to determine the success rate of obtaining accurate values of the ocular parameters that determine the refractive error of the eye of elementary school age students.

Methods

Ethics Statement

All of the procedures used conformed to the tenets of the Declaration of Helsinki, and they were approved by the Ethics Committee of Kagoshima University Hospital. A written informed assent and informed consent were obtained from all subjects and their parents. This study was registered with the University Hospital Medical Network-clinical trials registry (No. UMIN000015239).

Subjects

This study was part of a prospective, longitudinal, observational study of third grade students who were 8- to 9-years old at the first examination. The students attended the Elementary School of the Faculty of Education of Kagoshima University. There were 144 students in the third grade. An informed assent and consent were obtained from 122 (87.4%) students and their parents. The students were examined from November 17 to December 18, 2014 in the initial year and were examined during the same period annually for two years when they were in the fourth and fifth grade. Seven students were excluded due to truancy or transfer. In the end, the right eyes of 115 students were used for the analyses.

SS-OCT Optical Biometry Measurements

The SS-OCT optical biometric measurements were made with the OA-2000 Optical Biometer with the V.1.0.G to 3.0.B software (TOMEY, Nagoya, Japan) by one experienced examiner (TY).[26] The subjects were placed in a dimly lit room with natural pupils and instructed to place their chins on the chin rest, and the head was held firmly against the head holder with a brow band. They were then asked to fixate a target in the center of the visual field with both eyes open. Before beginning the measurements, the subjects were instructed to blink several times to ensure that the tear film was covering the entire corneal surface to create a smooth optical surface. The automatic measurement mode of the OA-2000 was used which auto-calibrates and automatically collects the values. Measurements were repeated if "error" or minus signals were displayed. For each scan, ten measurements of each parameter were acquired. A previous study on children showed that the intraclass correlation coefficients of repeatability and reproducibility were >0.967, and the coefficient of variation was ≤1.23% for all parameters by this device.[20] Therefore, we tried to obtain analyzable measurements three times. If the first measurement was successful in all ocular biometrics, we did not perform further measurements. If the second or third measurement failed for some variables, we chose the results in which the most variables could be measured. To avoid the effects of the correlation between the eyes of the same subject on the results, only the data of the right eye were measured.

The AL, CCT, ACD, LT, PD, CD, and CC were measured annually for three years without cycloplegia, and the success rate of obtaining optical biometric measurements was investigated.

Statistical Analyses

All statistical analyses were performed with the SPSS statistics 21 for Windows (SPSS Inc., IBM, Somers, New York, USA). The CD, which had a low measurement success rate, was divided into a successful group and a failed group, and the statistically significant differences in AL and sex distribution were determined by Mann–Whitney tests or the Chi square test.

Table 1 Success Rate of Ocular Biometry Measurements

Grade	Axial Length	Central Corneal Thickness	Anterior Chamber Depth	Lens Thickness	Pupil Diameter	Corneal Diameter	Corneal Curvature	n
Third	100%	100%	92.2%	88.7%	100%	84.3%	100%	115
Fourth	100%	100%	100%	99.1%	96.6%	66.1%	100%	115
Fifth	100%	100%	100%	100%	100%	100%	100%	115

Results

There were 56 boys and 59 girls who completed this study. When we performed the SS-OCT biometric measurements, we also performed OCT examinations and color fundus photography. We confirmed that all participants had healthy eyes. The AL, CCT, and CC could be measured in all cases in all grades. The success rate of the measurements of the ACD was 92.2% (106/115) in the third grade and 100% in the fourth and fifth grades. The success rate for the LT was 88.7% (102/115) in the third grade, 99.1% (114/115) in the fourth grade, and 100% in the fifth grade. The success rate for the PD was the 100% in the third grade, 96.6% (111/115) in the fourth grade, and 100% in the fifth grade. The CD was successfully measured in 84.3% (97/115) in the third grade, 66.1% (76/115) in the fourth grade, and 100% in the fifth grade (Table 1).

Of the 9 failed cases (7.8%) of the ACD measurements in the third grade, both the ACD and LT could not be measured in 7 eyes, and the summed value of the ACD and LT was measured as the ACD incorrectly in 2 eyes (Figure 1A and B). In the four failed cases in the students in the third grade, the ACD could be measured correctly but the LT could not be measured (Figure 1C and D). Of the 9 failed cases (7.8%) of the ACD measurement in the third grade, the ACD and LT could not be measured in 7 eyes. The summed values of ACD and LT was incorrectly measured as the ACD in 2 eyes (Figure 1A and B). In the 4 students in the third grade, the ACD could be measured but the LT could not be measured (Figure 1C and D).

The CD in the third and fourth grade, which had a low measurement success rate, was divided into a successful group and a failed group. The effects of the differences in the AL and sex distribution between the two groups were examined. The AL was not significantly different between the two groups in the third (P = 0.09) and fourth grades (P = 0.88). The

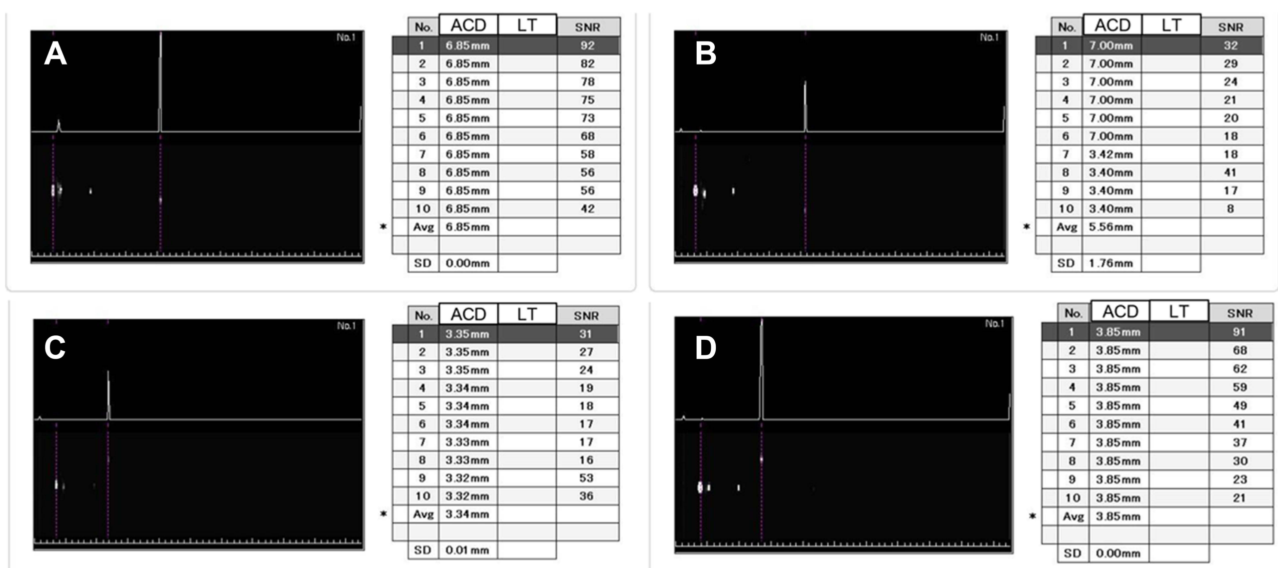

Figure 1 Representative cases of failed measurements of the anterior chamber depth (ACD) and lens thickness (LT). The total values of the ACD and LT were incorrectly measured as the ACD in all 10 cases (**A**) and 6 of 10 measured cases (**B**). Cases in which the ACD was measured successfully, the LT could not be measured (**C** and **D**).

failure of the CD measurements was more frequent in boys than in girls in the fourth grade (P = 0.018) but not in the third grade (P = 0.053).

Discussion

Our results showed that SS-OCT biometry can measure all of the ocular biometric parameters in all students in the fifth grade (10- to 11-years-old). Even in the third and fourth grades (8- to 10-years-old), the AL, CC, and CCT could be measured successfully in all cases. These variables are essential for myopia studies and for the calculations of the lens power. On the other hand, the ACD, LT, PD, and CD were not measured accurately in some cases. Tehrani et al reported that the optical biometric measurements of 44 of 253 (17%) adult eyes scheduled for cataract surgery were not possible. Failed measurements were the result of a combination of low visual acuity, unsteady fixation, and lens opacities in 45% of the eyes, posterior subcapsular opacity in 25%, and macular disease in 7%.[16] It is not clear whether there were cases in which the measurements were unsuccessful in the repeated studies of healthy eyes in adults and children.[20,21] It is likely that all measured variables could be measured in all healthy eyes of adults. However, the results of our study suggest that caution is necessary when assessing the ACD and LT measurements in children of the ages studied. In the case shown of Figure 1A, the total values of ACD and LT were incorrectly measured as the ACD in all ten measurements. Considering the average ACD in children is around 3.6 mm,[25] it is easy to exclude these cases with an improbable value by examining the distribution. In the case shown in Figure 1B, the total value of ACD and LT was incorrectly measured as the ACD in the first to sixth measurements, and the seventh to tenth measurements may be the correct value. If the measurement error is made only once, it is difficult to detect it without referring to the figure measured ten times instead of the average value. Therefore, a careful examination is needed in assessing the ACD and LT measurements especially in a large-scale study of elementary school students.

The possible reasons for these inaccurate measurements is the lens clarity and the detection program of the instrument. For example, in Figure 1C and D, there was no refraction line of the posterior of the lens. The index of lens transparency, ie, lens thickness and light scattering effects, gradually increases due to aging even in eyes of young normal subjects.[27] The clearer lens in children younger than 10-years-of-age may lead to exceeding the detection limit of the SS-OCT ocular biometer. Although there were refraction lines at the anterior and posterior of the lens in Figure 1A and B, the instrument could not detect the accuracy lines. The success rates for ACD and LT were gradually improved and became 100% in the eyes of fifth graders. Although it is unavoidable in a longitudinal study, the version of the embedded software improved from 1.0.G to 3.0.B during this period. This advanced version of the embedded software may affect not only the success rate of ACD and LT but also that of the CD.

In the CD measurements, 18 eyes of third grade students failed, and 39 eyes of fourth grade students failed. Only 8 eyes failed in the subsequent visit, and there was no particular tendencies. These measurements were performed by holding the eyelid open by the students, and the CD was measured in the later part of the measurements. Additionally, the CD measurements required a larger eyelid opening than the other measurements. Self-opening of the eyelid may improve with aging. These factors may affect the low acquisition rate of the CD measurement in the third and fourth grade students.

The failure of the measurements of the VD was more frequent in boys than in girls in the fourth grade. A previous study showed that the spontaneous blink rate was significantly higher in women than in men.[28] This is the opposite of the results of our study. So, we cannot present a definitive reason for the sex differences.

There are limitations in this study. First, this was a small-scale longitudinal study of a limited number of elementary school students, and a learning effect may affect the results even in annual examinations. A cross-sectional large-scale study is needed to confirm this. Second, we made the measurements without cycloplegia. Unfortunately, an agreement of parents was not always obtained. This may have affected the ACD and LT measurements. On the other hand, the LT with cycloplegia is not the natural value while the LT without cycloplegia is the natural status of the lens.

In conclusion, SS-OCT optical biometry was able to measure all variables in all cases of fifth-grade primary school students. Even in the third and fourth grades, the AL, CT, and CC were able to be measured in all cases, but the ACD, LT, PD, and CD could not in some cases. These findings, especially the total value of the ACD and LT, were incorrectly measured as the ACD, should be remembered in interpreting the biometric data of the eyes of children.

Abbreviations

AL, axial length; SS-OCT, swept-source optical coherence tomography; CCT, central corneal thickness; ACD, anterior chamber depth; LT, lens thickness; PD, pupil diameter; CD, corneal diameter; CC, corneal curvature.

Statement of Ethics

All of the procedures used conformed to the tenets of the Declaration of Helsinki, and they were approved by the Ethics Committee of Kagoshima University Hospital. A written informed assent and informed consent were obtained from all subjects and their parents. This study was registered with the University Hospital Medical Network-clinical trials registry (No. UMIN000015239).

Funding

The funding organizations had no role in the design or conduct of this research. This study was supported by JSPS KAKENHI, grant number 21H03095, 21K09704 and by the Suda Memorial Glaucoma research grant.

Disclosure

Dr Takehiro Yamashita reports grants from Alcon and Novartis, outside the submitted work. The authors declare that they have no other conflicts of interest in this work.

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