Original article

Development of a training system for manual kinetic perimetry using the Goldmann perimeter

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Abstract

The Goldmann perimeter (GP) has been widely used in manual kinetic perimetry because it can measure an overview of the visual field in a relatively short period of time. However, its results can be considerably influenced by the examiner's skill and is therefore examiner-dependent. The examiner's skill can only be improved through repeated practice of Goldmann manual kinetic perimetry (Goldmann MKP). Therefore, we have developed a Goldmann MKP training system as sort of patient simulators using the GP, and we have attempted to introduce it into the education for orthoptists.

In this system, the computer is connected to a pen tablet mounted on the GP. Goldmann MKP practice software is loaded on the computer. It is possible to record the position of the target moved by the trainee during visual field measurement. The computer beeped when the location of the target reached the threshold of the visual field. With a conventional Goldmann MKP original recording sheet, it was not possible to look back on the maneuvers leading up to the test results. The information recorded in the present system enabled detailed recordings of the track of the target that was moved by the trainee. This information provided an opportunity for the supervisor to review the procedural skills of each trainee and provide specific feedback on performance.

Introduction

A majority (90.7%) of orthoptists are engaged in kinetic perimetry [1]. All orthoptist training institutions engage in practical instruction for kinetic perimetry [2]. Conventional Goldmann manual kinetic perimetry (Goldmann MKP) has many advantages over other perimetry techniques. Goldmann MKP can measure an overview of the visual field in a relatively short time. However, results can be considerably influenced by the examiner's skill. The examiner's skill can only be improved by repeated experience with Goldmann MKP. Orthoptic students require a long time to measure Goldmann MKP for patients in clinical situations even though they have enough practice in their institution. Orthoptic students cannot easily acquire necessary experience due to the consequent physical burden. In addition, the

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orthoptist having little experience visual field tests for patients is hard to obtain test results with diagnostic value in the measurement of visual field defects.

Goldmann MKP technical check sheet was developed for Goldmann MKP training by Kobayashi [3], who reported that the check sheet was effective in confirming the trainee's basic testing maneuvers and clarifying the content of instruction. In addition, Schiefer et al [4] developed a computer-based teaching procedure for kinetic perimetry that incorporated an evaluation system for scoring an examination technique using the OCTOPUS 101 (Vision Systems, Tarpon Springs, FL, USA) perimeter. There is no training system that simulates actual visual field testing with the Goldmann perimeter (GP). We have developed a Goldmann MKP training system using the GP and have tested it in orthoptist's education.

Materials and Methods

1. Experimental setup of a training system for Goldmann MKP

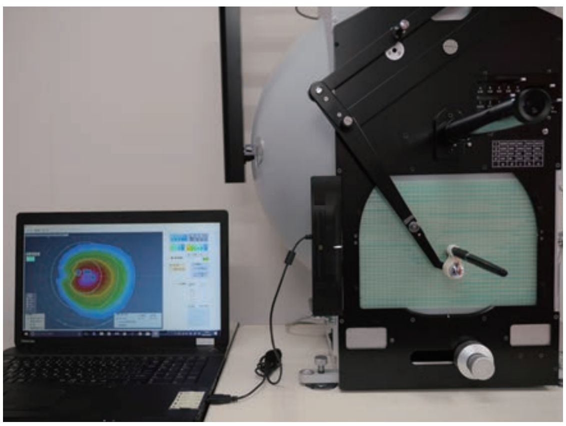

Figure 1. A training system for the measurement of manual kinetic perimetry using the Goldmann perimeter.

In this system, the computer is connected to a pen tablet mounted on the GP. Goldmann MKP practice software is loaded on a computer (Figure 1). The software was developed with Visual Basic. NET 2010 (Microsoft). To record the measurement procedure, the sensor unit of a slim pen tablet (PTB-STRP1, PRINCETON) was placed behind the recording sheet, and a touch pen was installed on the tip of the pantograph (Figure 2).

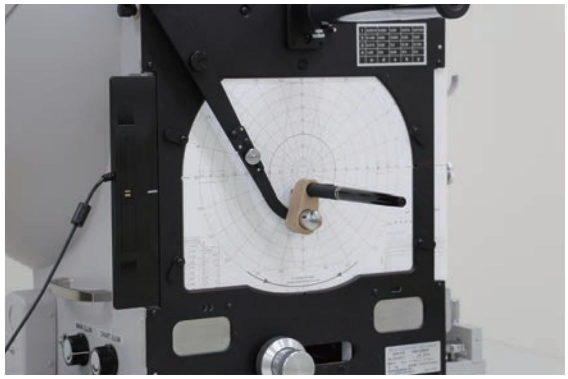

Figure 2. The pen tablet used in our system.

In this system, the examiner measured a simulated patient's visual field. To create simulated patient, the first step is to capture an image file of the results of Goldmann MKP and import it into the software. The next step is to manually plot the points on the isopters. The position of the points were recorded in 0.5 degree increments. Finally, the points are connected (Figure 3-a). The sensitivity distribution was calculated based on the stimulus intensity of the target and each interval between adjacent isopters (Figure 3-b).

During visual field measurement using this system, the position of the target moved by the examiner was recorded at intervals of 0.2 seconds. The computer beeped when the location of the target reached the threshold of the visual field. When the beep sounded, the examiner clicked the touch pen to signify a response at that position. After the click, the point was plotted on the computer screen (Figure 4), and the examiner marked a check on a recording sheet with a pencil.

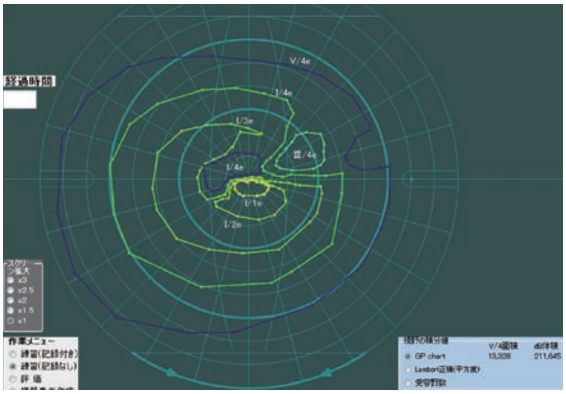

Figure 3-a. The simulated patient's visual field data imported from the results of Goldmann MKP.

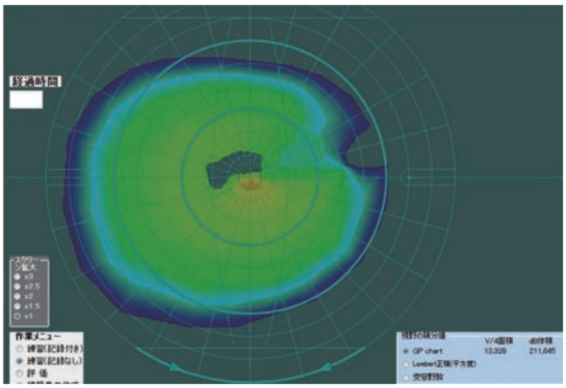

Figure 3-b. Visual field sensitivity distribution interpolated from isopters.

The brightness and size of the target were changed using a special keyboard connected to the computer.

2. Subjects and Methods

The subject was a female trainee (age 20 years), who was an orthoptic student with no practical experience with Goldmann MKP in a clinical setting. The control subject was a female orthoptist (age 50 years) with 26 years of clinical experience. The trainer was a male orthoptist (age 28 years) with 3 years of clinical experience.

The trainee used this system to measure a

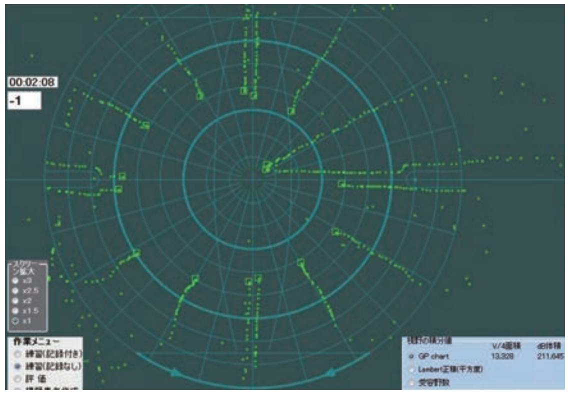

Figure 4. Examination window of the training software.

The dots show the movement of the target by the examiner. The squares (□) show the points plotted when the examiner clicks the touch pen. The movement of the target and the plotted points are color-coded by the size and brightness of the target.

simulated patient's visual field. The trainer monitored on the computer the movement of the target by the trainee during measurement. The experienced orthoptist also measured Goldmann MKP for the same simulated patient. The simulated patient's data was a glaucomatous visual field defect with arcuate defects; this simulation was based on data recorded in a clinical situation (Figure 5-a). The trainer advised the trainee on Goldmann MKP methods using both the results recorded in this system and the original recording sheet of Goldmann MKP after measurement.

After receiving instruction from the trainer, the trainee performed Goldmann MKP again for a simulated patient with a glaucomatous visual field defect that differed from the previously used simulated patient (Figure 5-b). The track of the target movement, brightness and size of the target selected by the trainee, and the number of checks (plots) were evaluated to determine the trainee's improvement in Goldmann MKP measurement skill after instruction.

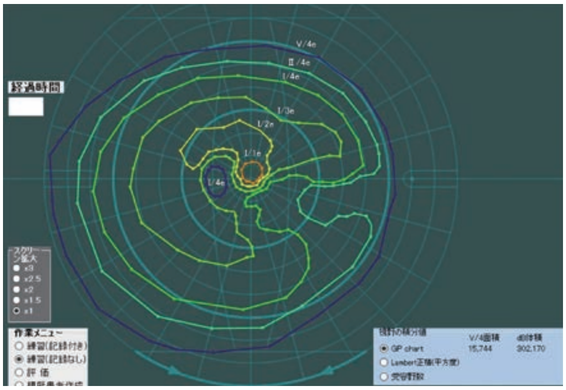

Figure 5-a. Visual field data measured prior to instruction from the trainer.

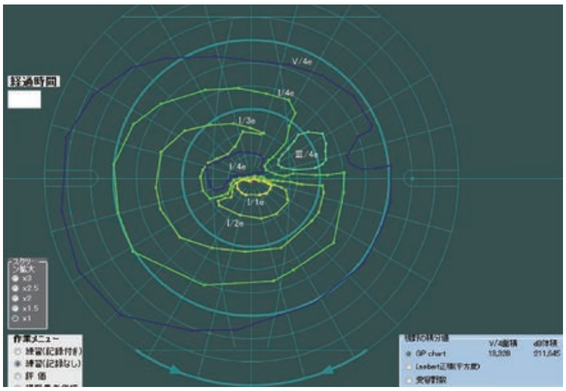

Figure 5-b. Visual field data measured after instruction from the trainer.

This study has been approved by the Ethics Committee of Niigata University of Health and Welfare (Approval No: 17791-170303).

Results

1. A comparison of Goldmann MKP results between the training system and the original recording sheets

Figures 6-a and 6-b show the Goldmann MKP original recording sheets made by the trainee and the experienced orthoptist, and Figures 7-a and 7-b show data recorded in the training system. On the original recording sheets, there were differences in I/3e isopter detection between the trainee and the experienced orthoptist in Goldmann MKP in the area 10º–20º from the center of the visual field, which corresponded to Bjerrum's area. The experienced orthoptist detected a scotoma that demonstrated reduced sensitivity in Bjerrum's area, which the trainee failed to detect. The experienced orthoptist's target presentation focused on predicted sites of reduced sensitivity in the visual field. However, the trainee did not present the target to sites of reduced sensitivity in the visual field toward the center as much as to other points. The target movement track recorded in the system revealed that the trainee's movement of the target was insufficient for detecting the Bjerrum scotoma

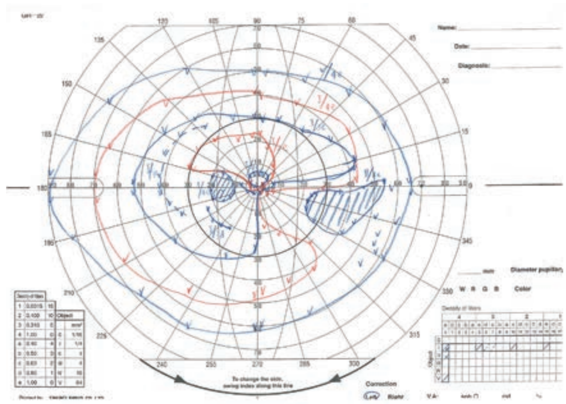

Figure 6-a. Trainee's Goldmann MKP original recording sheet.

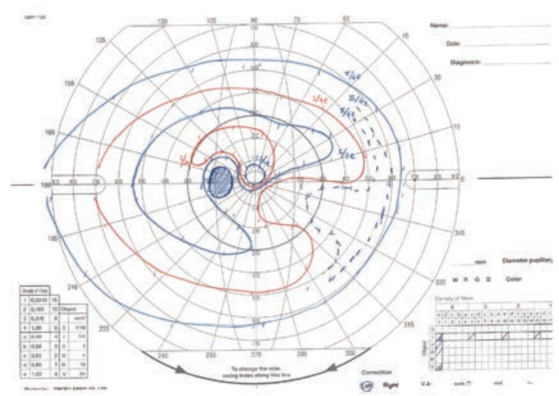

Figure 6-b. Experienced orthoptist's Goldmann MKP original recording sheet.

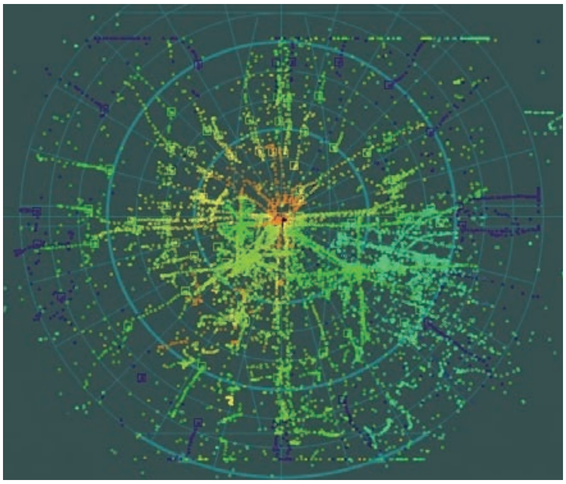

Figure 7-a. Trainee's data recorded in the training system.

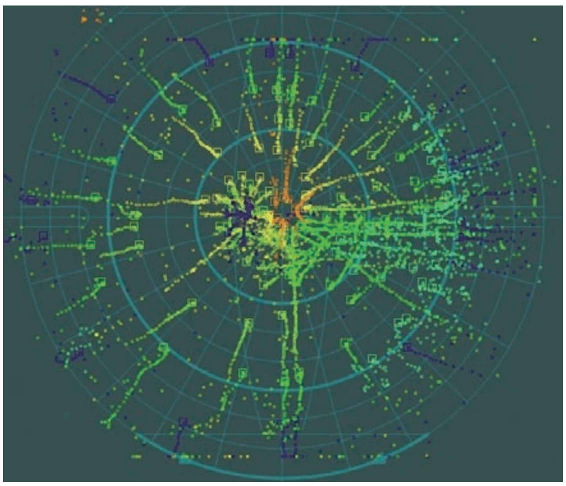

Figure 7-b. Experienced orthoptist's data recorded in the training system.

(Figure 8-a). In addition, while the trainee and the experienced orthoptist both detected I/4e isopters using Goldmann MKP on the original recording sheet, the information recorded in the system revealed differences in their movements of the target. The trainee began moving the target from the same point each time. On the contrary, the experienced orthoptist presented multiple targets while changing the track presentation starting point and the direction of target movement on the track

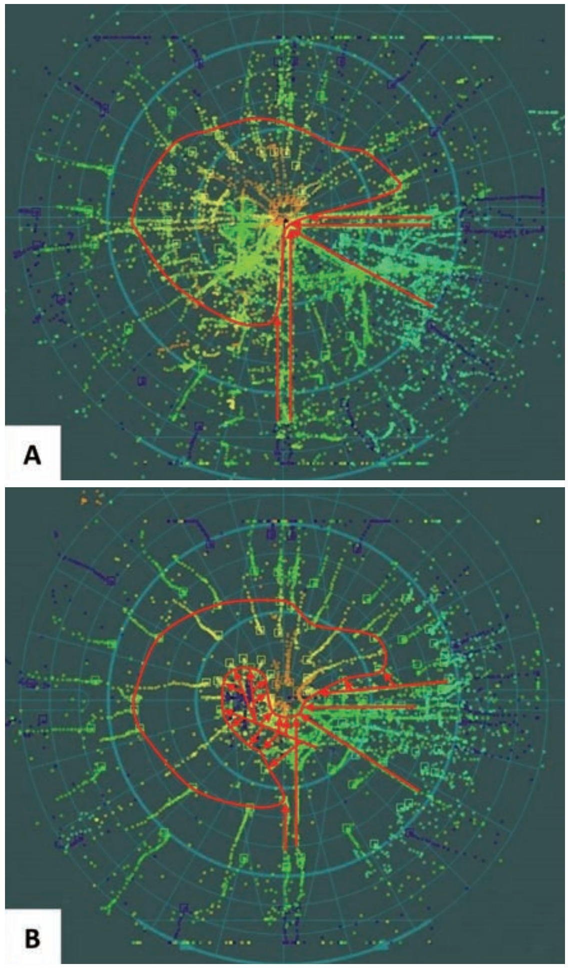

Figure 8-a. Difference in isopter detection between the trainee and the experienced orthoptist.

A shows the trainee's data, and B shows the experienced orthoptist's data. The solid red line indicates I/3e isopter, and red arrows indicate the directions of the target movement. The trainee exhibits the targets along the horizontal, vertical and intermediate meridian, whereas in comparison the experienced orthoptist exhibits more targets to detect the decline in visual field sensitivity. Originally, solid lines and arrows did not appear in the examination window.

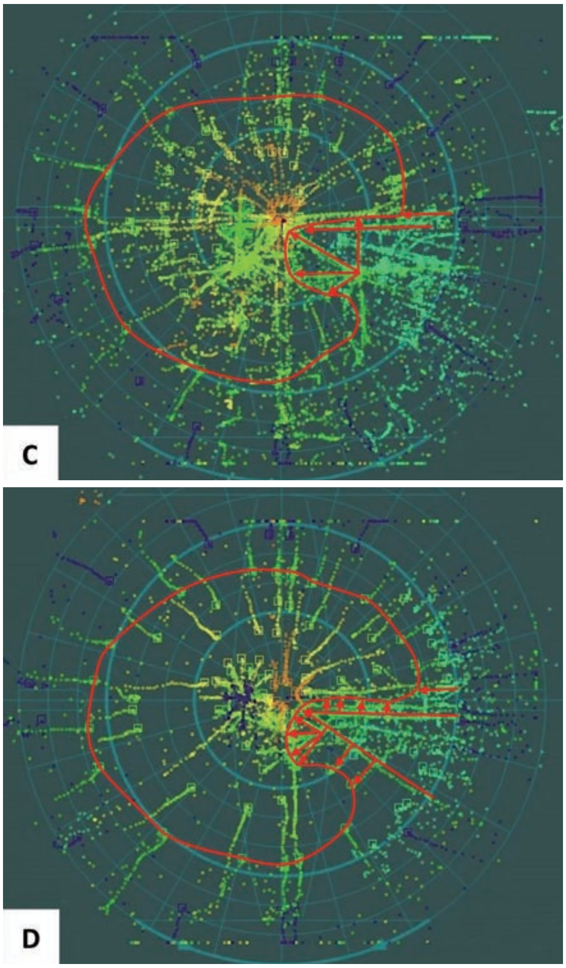

Figure 8-b. The points where the trainee and experienced orthoptist detected similar isopters.

C shows the trainee's data, and D shows the experienced orthoptist's data. The solid red line indicates I/4e isopter, and red arrows indicate the directions of the target movement. The trainee began moving the targets from the same point, whereas the experienced orthoptist present the targets efficiently from the tracking positions lacking a simulated patient's response (beep). Furthermore, compared to the trainee, the experienced orthoptist presents more targets to detects isopter accurately.

where a beep did not sound. In visualization of the Bjerrum scotoma, the trainee plotted only one point, whereas the experienced orthoptist plotted four points (Figure 8-b).

The results recorded on the original training sheet and in the system demonstrated the trainee's error in visual field testing and the cause of the error. The results of the trainee's visual field measurement recorded on the original recording sheet and in the system served as a basis for the trainer to instruct the trainee in correct GP method and Goldmann MKP measurement. The trainer instructed to the trainee as follows: (1) to move the target adequately to the section where the visual field sensitivity was lowered, and (2) not to move the target from the same point, but to change the start position efficiently to the point where the beep did not sound.

2. Feedback-based improvement in trainee's Goldmann MKP skill

Figures 9-a and 9-b show the trainee's performance following instruction by the trainer. On the original recording sheet, the trainee was found to have properly detected the reduced sensitivity in the Bjerrum's area (I/3e isopter). The data captured by the system demonstrated that the

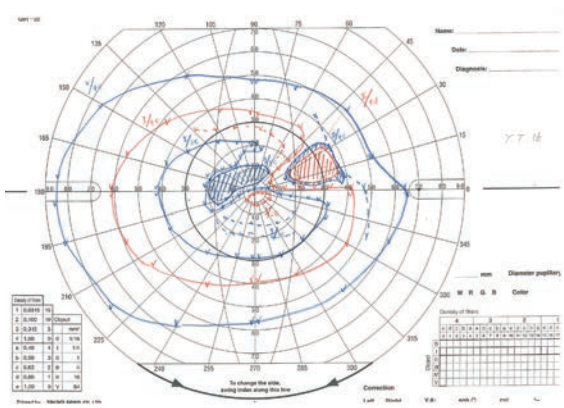

Figure 9-a. Trainee's Goldmann MKP original recording sheet after receiving instruction from the trainer.

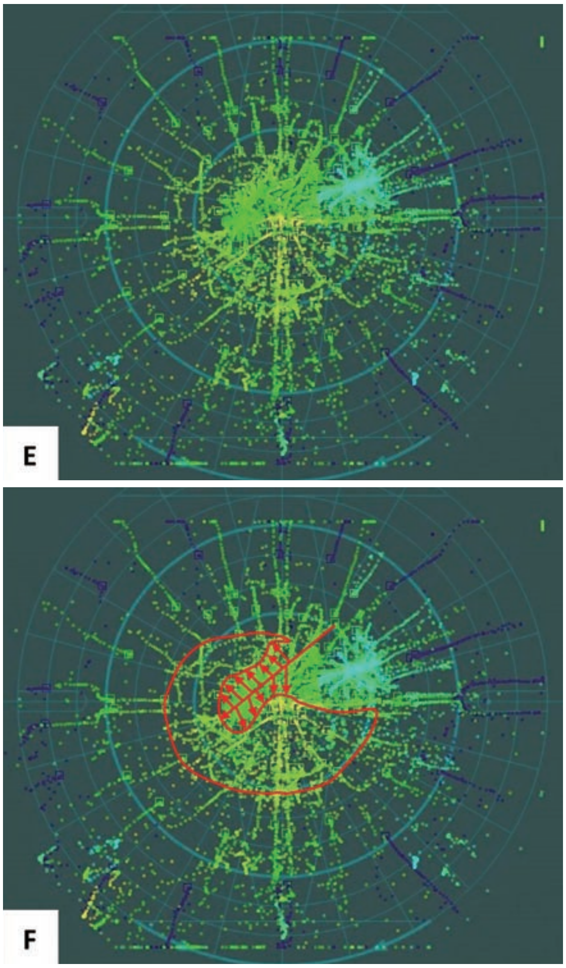

Figure 9-b. Trainee's data recorded in the training system after receiving instruction from the trainer.

E shows original data, and F shows isopter and directions of the target movement. The solid red line indicates I/3e isopter, and red arrows indicate the directions of the target movement. The trainee present multiple targets while changing the track presentation starting point and the direction of target movement on the track where a beep did not sound.

trainee's presentation of the target was adequate with respect to the section where the visual field sensitivity was lowered. In addition, the trainee presented the target branched from the track on which the simulated patient did not respond. It was confirmed that the trainee was performing Goldmann MKP according to the instructions provided by the trainer. The data recorded by this system confirmed the trainee's movement of the target, which cannot be confirmed on an original recording sheet.

Discussion

The ideal method to improve the Goldmann MKP testing skill is repeated practice through performing multiple Goldmann MKP tests on patients with visual field defects. However, orthoptic students have few chances to practice Goldmann MKP on actual patients, limiting opportunities to improve their testing skills. To address this issue, we have developed a Goldmann MKP training system and have tested it in the education of orthoptists. Our training system enable to train any number of times in a variety of visual field defects without actual patients. It also possible to make a comparison between the data of Goldmann MKP from orthoptic students and experienced orthoptists to same simulated patients.

Regarding Goldmann MKP, Kobayashi et al [5] have stated that orthoptic students lack a sufficient image of patients with visual field defects, causing them to overlook defects or mistakenly create visual field defects that actually does not exist The system in the present study can be loaded with visual field defect data to create simulated patients on which trainees can practice, thereby giving trainees the opportunity to self-instruct repeated tests on the same visual field. In addition, preparing various types of case data enables visual field test practice for various types of visual field defects. Although it is difficult for orthoptic students to gain experience in Goldmann MKP on clinical patients, our system creates an opportunity to improve Goldmann MKP skills. In conventional Goldmann MKP, the only items recorded by the examiner on the original recording sheet are the checks (plots) and isopters. As a result, it was not possible to review the maneuvers leading up to the test results. By constantly recording touch pen movements on a pen tablet, the present system can record not only the points where the patient responded but also the track of the target moved by the examiner. In the present study, the utilization of the information recorded in our system in practical Goldmann MKP instruction for orthoptic students enabled detailed confirmation of the examiner's movement of the target, which cannot be evaluated with an original recording sheet alone. Understanding the track of the target during visual field measurement can lead to specific instruction to improve testing skills, which is beneficial for both the trainee and the orthoptist trainer.

Schiefer et al [4] developed a computer-based teaching procedure for kinetic perimetry, which incorporated an evaluation system for scoring examination technique using the OCTOPUS 101 Perimeter, which improved trainees' testing skill. Semi-automated kinetic perimetry, such as the OCTOPUS 101 Perimeter, can be used in kinetic visual field testing, but it automatically measures the visual field according to the testing maneuvers entered by the operator. Although there have been studies on the effectiveness of semi-automated kinetic perimetry [6] and studies on semi-automated kinetic perimetry measurement strategies [7], semi-automated kinetic perimetry has not been put into practical use in Japan.

In conclusion, our system enabled the simulation of Goldmann MKP testing under conditions closely resembling a clinical situation. However, practice measurements on simulated patients cannot completely replicate real-world patients and the psychological tension that the orthoptist feels in such settings. In the future, these challenges need to be discussed in more detail.

Acknowledgments

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Conflicts of interest

None of the authors has any conflicts of interest or any financial ties to disclose.

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