Efficacies of preoperative prism adaptation test and monocular occlusion for detecting the maximum angle of deviation in intermittent exotropia

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Declarations

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Abstract

Background: The efficacies of prism adaptation test (PAT) and monocular occlusion (MO) and their optimal test durations to detect the maximum angles of deviation at near and distance in eyes with intermittent exotropia (IXT) were assessed and compared.

Methods: We retrospectively reviewed the medical records of 72 patients with IXT, who had undergone the initial strabismus surgery between April 2015 and October 2018 and had been preoperatively tested by PAT and MO. The near and distance deviations measured after 30- and 60-minute PAT and MO were compared with the baseline measurements obtained immediately after prism wear and before occlusion. The measurements and the required durations for obtaining the maximum deviation angle were also compared between PAT and MO.

Results: Compared with the baseline, the near deviation by PAT significantly increased after 30 (p < 0.05) and 60 (p < 0.01) minutes but not the distance deviation. Besides, the increase in the near deviation after 30 minutes was not significant. By MO, neither near nor distance deviation showed a significant difference from the baseline after 30 and 60 minutes. While the near deviations by PAT were significantly greater than those by MO at 30 and 60 minutes, a similar result was only observed at 30 minutes in the distance deviation.

Conclusion: A 30-minute PAT appears to be more effective than MO in revealing the maximum angle of deviation before strabismus surgery.

Keywords Intermittent exotropia, Prism adaptation test, Monocular occlusion, Maximum angle of deviation
Background

Intermittent exotropia (IXT) is an outward deviation that breaks down spontaneously into a manifest exotropia and has two states, exotropia and exophoria. With the ultimate goal to preserve patient’s good binocular vision and ability to maintain phoria, treatments for IXT include strabismus surgery, prism therapy, and orthoptics [1].

By surgically correcting the amount of deviation to maintain phoria, strabismus surgery is usually the surgeon’s first choice especially in cases with large deviations. However, the issues of inconsistent surgery outcomes and postoperative recurrence remain challenging [2].

The performed surgical procedure [3], a young age at surgery [2], presence of suppression [1], and an underestimated angle of deviation [4] have been described as the factors for postoperative recurrence. The angle of deviation is usually measured using the alternate prism cover test (APCT). Pritchard [4] and Kushner [5] have emphasized the significance of detecting the maximum deviation that determines the required amount of surgery and leads to the prevention of postoperative recurrence. However, revealing the true deviation would be difficult if fusion cannot be sufficiently removed during APCT. Particularly in eyes with IXT, any anxiety caused by the surrounding during the test could make it difficult for the tested eye to break fusion. Besides, fusion may not be sufficiently removed depending on the skill of the examiner. The reported influences of tenacious proximal fusion (TPF) [6] (Scobee phenomenon [7]) and tenacious distance fusion [5] could also prevent IXT patients from revealing the true deviation during APCT. Therefore, a method other than APCT which can measure the maximum angle of deviation before strabismus surgery is clinically essential to the management of IXT.

The prism adaptation test (PAT) and monocular occlusion (MO) are two effective methods to reveal the
maximum angle of deviation [8, 9]. PAT reveals the maximum deviation using a prism that neutralizes the deviation and controls fusion, and MO brings out the underlying deviation by eliminating fusion with the occlusion. Good surgical outcomes obtained with the surgical doses based on the angles of deviations measured after PAT and MO have been reported in patients with IXT [10-12]. While some studies concluded that PAT and MO are comparable in revealing the maximum deviation [13, 14], other studies reported the superiority of PAT over MO for obtaining a greater deviation [15-18] and no consensus has been reached. One reason for the lack of consensus could be the debatable optimal duration (prism wearing time for PAT and total occlusion time for MO) required to detect the maximum deviation that varies among researchers [10, 11, 15, 16, 19-26]. To our knowledge, no study has been conducted in the same group of subjects to investigate the required optimal PAT and MO durations.

In this study, we aimed to compare the efficacies of preoperative PAT and MO for revealing the maximum angle of deviation within the same test duration and to determine the optimal test durations for both methods.

Methods

Patients

Subjects in this retrospective study were 72 patients (34 males and 38 females) with IXT, who had received the initial strabismus surgery at Kindai University Hospital between April 2015 and October 2018. All the subjects had corrected visual acuity of 1.0 (LogMAR equivalent 0.0) or better and received preoperative PAT and MO for 30 and 60 minutes. Exclusion criteria were patients with previous strabismus surgery, a vertical deviation angle
of $\geq 5$ prism diopter (PD), and a dissociated vertical deviation.

The subjects’ age at time of test ranged from 6 to 76 years (mean, 19.0 $\pm$ 18.1 years) and 54 (75%) were under the age of 19. By APCT, the subjects’ distance (5 m) and near (30 cm) deviations (mean $\pm$ standard deviation) were 26.4 $\pm$ 6.6 PD and 31.0 $\pm$ 6.8 PD, respectively. The IXT types were classified as follows: basic type with a near/distance deviation difference of $< 10$ PD, convergence insufficiency type with near deviation $>$ distance deviation for more than 10 PD, and divergence excess type with distance deviation $>$ near deviation for more than 10 PD. Of 72, 60 patients had basic type, 12 patients had convergence insufficiency type, and no patient had divergence excess type of IXT.

The protocol for this study was approved by the ethics committee of Kindai University and adhered to the tenets of the Declaration of Helsinki. Informed consent was obtained from all the patients.

**Test methods**

Using the dominant eye as the fixating eye, angles of deviation were measured by APCT with complete correction at distance (5 m) and near (30 cm). To completely eliminate fusion, the examiner used a long cover to ensure that the eyes were not under binocular viewing when alternating the prisms. In the PAT, a prism with the distance deviation measured by APCT was applied over the patient’s non-dominant eye. The deviation angles immediately after prism wear (the initial angle) and at 30 and 60 minutes were measured. In the MO test, the non-dominant eye was occluded and the deviation angles before occlusion (the initial angle) and at 30 and 60 minutes after occlusion were measured. The PAT and MO test for each patient were performed on different days.
by the same examiner.

Using the initial angle as the baseline measurement, the deviation changes after 30 and 60 minutes were assessed for each test, and a comparison between the PAT and MO measurements was also made.

### Statistical analysis

Statistical analysis used the Steel-Dwass method to compare the angles after 30 and 60 minutes with the initial angle. The Wilcoxon signed-rank test was used to compare the deviation changes between PAT and MO.

Probability values less than 0.05 were considered statistically significant.

### Results

#### Changes in the near and distance deviations after 30 and 60 minutes of PAT and MO

Table 1 shows the deviation angles measured at baseline and after 30- and 60-minute PAT and MO. Compared with the baseline PAT measurement, significant increases in the near deviation (mean ± SD) were observed after 30 minutes (3.5 ± 3.9 PD, \( p < 0.05 \)) and 60 minutes (4.1 ± 3.9 PD, \( p < 0.01 \)). Although the near deviation at 60 minutes was slightly larger than that at 30 minutes, the difference (0.6 ± 1.3 PD) was not significant. The distance deviations at 30 and 60 minutes did not significantly differ from the baseline measurement. Compared to the deviations before MO, neither near nor distance deviation significantly increased after 30 and 60 minutes of MO.

#### Comparison between the PAT and MO measurements
The near deviations by PAT at 30 and 60 minutes were significantly greater than those by MO (p < 0.01, Wilcoxon signed-rank test; Fig. 1). PAT also showed a significantly greater distance deviation than MO at 30 minutes (p < 0.05, Wilcoxon signed-rank test; Fig. 2) but not at 60 minutes.

**Changes of patients’ IXT types**

With increased near deviations after PAT, 9 (15%) of the 60 patients with basic type of IXT converted to convergence insufficiency type. In these patients, the near/distance deviation differences by APCT and PAT were 5.6 ± 1.0 PD and 10.4 ± 0.9 PD, respectively. The 12 patients with convergence insufficiency type of IXT before PAT remained the same after PAT.

**Discussion**

With a 60-minute test duration for PAT and MO, the angles of deviation measured after PAT were larger than those measured after MO. Furthermore, significant differences in near and distance deviations were only observed at 30 minutes and no significant difference was seen after 30 minutes between both methods. These results demonstrated the efficacy of a 30-minute preoperative PAT and suggested that the stabilized fusion by prism adaptation (PA) could be more effective than the eliminated fusion by MO for revealing the maximum angle of deviation in IXT.

The current result showed that the angles of exodeviation measured after PAT were significantly larger than those after MO and this was in agreement with previous results [15-18]. The PAT and MO measurements may be
comparable, but a larger angle of deviation after MO has not been reported previously. These results suggest that the preoperative use of PAT could be more effective than MO in revealing the maximum angle of deviation in IXT. During PA, motor fusion is suppressed and sensory fusion stability is sustained in order for the displaced retinal image to be fused on the two fovea centralis. Unlike MO that eliminates fusion with occlusion, PA brings sensory fusion into a stable status under binocular viewing and thus could better elicit the underlying deviation.

The PAT measurements at near showed a greater increase than the measurements at distance in this study. A previous study has reported a similar observation [19]. Furthermore, 9 patients with a basic type of IXT converted to a convergence insufficiency type due to their increased near deviations. Reportedly, vergence aftereffect (or slow vergence) which is a temporary change in eye position resulted from sustained fusional convergence could mask the true near deviation in IXT and result in underestimated near deviation [26-29]. In addition, proximal convergence and vergence aftereffect also cause a higher accommodation convergence / accommodation (AC / A) ratio in IXT [30]. On the other hand, a smaller AC/A ratio is observed after PAT [15]. With PAT showing the maximum angle of near deviation in this study, we therefore suspected that PA might have eliminated the influence of proximal convergence and vergence aftereffect and elicited the true underlying near deviation.

The MO measurements did not significantly differ from the baseline measurement by APCT, and the measurements at distance and near were all smaller than those by PAT. Hans and colleagues reported that the average maximum angles of deviation measured at distance and near on 3 or more examinations before MO are larger than those measured after 1-hour MO [31]. This suggests that 1-hour MO may not be able to reveal the same amount of deviation as 1-hour PAT. Furthermore, since MO and APCT share the same mechanism that eliminates
fusion by occlusion, the eliminated fusion by MO may not be sufficient and this also explains why the maximum deviations by MO were smaller than those by PAT in this study.

Previously reported optimal PA time ranges from 30 minutes to 2 weeks [10, 11, 15, 17-19] and no consensus has been reached. A shorter prism adaptation time is always desirable especially in pediatric patients. Kushner and colleague concluded that a rapid (30 seconds to a few minutes) PAT that identifies the presence of TPF in IXT is qualitatively but not quantitatively equivalent to 1-hour of MO for determining deviations [13]. In this study, the near and distance deviations after 60 minutes of PAT did significantly differ from those after 30 minutes. Compared to the distance deviation by MO, a significantly larger angle of distance deviation by PAT was only observed at 30 minutes. These results suggest that a rapid PA may not be sufficient but 30 minutes of PA could have the potential to reveal the underlying deviation.

This study has some limitations. Because the occlusion and PA durations were set for 30 and 60 minutes, whether and how the angle of deviation would further change beyond 60 minutes was not clear. However, no subjects showed an increase of ≥ 5 PD between 30 and 60 minutes and the measurements at 30 and 60 minutes did not significantly differ. We therefore considered that deviation is unlikely to significantly increase after 60 minutes. In addition, the AC/A ratios before and after MO and PAT were not available and thus, the association between the AC/A ratio and the increase in the near deviation could not be examined.

In conclusion, PAT is more useful than MO for preoperative detection of the maximum deviation in IXT. The angles of deviation measured after 30 and 60 minutes of PAT did not significantly differ. Therefore, a 30-minute PAT has the potential to reveal the true underlying deviation in IXT.
List of abbreviations

IXT: Intermittent exotropia; PAT: Prism adaptation test; MO: Monocular occlusion; APCT: Alternate prism cover test; PD: prism diopter; PA: Prism adaptation; AC/A: Accommodation convergence / Accommodation
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Figure legends

Figure 1. The comparison of the near deviations by PAT and MO at the three time points.

While the baseline APCT measurements did not significantly differ, the PAT measurements at 30 and 60 minutes were significantly greater than the MO measurements. Analysis used the Wilcoxon signed-rank test (** $p < 0.01$, n.s.: not significant).

Figure 2. The comparison of the distance deviations by PAT and MO at the three time points.

The distance deviations by PAT were still greater than those by MO, but the differences were not as distinct as the differences seen in near deviation. Analysis used the Wilcoxon signed-rank test (* $p < 0.05$, n.s.: not significant).