# Comparison of Alternate Part-time Patching and Pencil Push-up Training for Patients with Intermittent Exotropia

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## Abstract

# Background

To compare the effect of alternate part-time patching and pencil push-up training on control ability in patients with intermittent exotropia.

# Methods

Patients (3-7 years of age) with previously untreated intermittent exotropia were randomly assigned to receive alternate part-time patching, pencil push-up training or observation. Control ability was assessed using the Office Control Score. Stereoacuity at 40cm was evaluated with Titmus. Results were compared after 12-weeks follow-up.

# Results

Ninety-two patients (28 in patching, 30 in pencil push-up and 34 in observation group) completed baseline and 12-week follow-up assessments. On the basis of 6-point scale, the mean deviation control was significantly better in patching and pencil push-up group after 12 weeks at distance (*P*=0.002 and 0.026, respectively). Furthermore, there was greater control changes in patching and pencil push-up groups in comparison with observation group from baseline to 12 weeks (P0.001;P=0.003, respectively). After 12 weeks of treatment, stereoacuity and stereoacuity changes were not significantly different between either of the intervention group and control group (P=0.140 and 0.393, respectively).

# Conclusions

Based on the common office control scales, alternate part-time patching and pencil push-up training were effective treatment strategies for intermittent exotropia.


## Introduction

Intermittent exotropia (IXT) is the most common type of strabismus and it is estimated that approximately 3% of Chinese teenagers suffer from this condition.[1] Different kinds of surgical and nonsurgical treatments were employed in management of intermittent exotropia.
Nonsurgical treatments include correction of refractive error, occlusion, prism therapy and overminus therapy.[2] Current evidence shows that conservative treatment has a negative effect on reducing angle of exodeviation and improving fusional amplitudes.[3-5] As we all know, control ability is becoming more important in determining the time of surgical management of intermittent exotropia.[6-7] It has important clinical application value to assess the impact of conservative treatment on IXT. Comparing to

other conservative treatment methods, alternate occlusion and pencil push-up training are easy-to-operate and inexpensive therapeutic modalities. To our knowledge, there is no previous study that compares the efficacy between the two treatments. This study aims to assess the impact of alternate part-time occlusion and pencil-up training on control ability of patients with intermittent exotropia.

# Methods

The informed consent was approved by Nanjing Children's Hospital Review Board for this study, parent or guardian of each subject signed the informed consent prior to treatment.

### Eligibility Criteria

In this study, the ages of subjects ranged from 3 to 7. The spherical equivalent refraction was between -6.00 diopter(D) and +1.00D. And patients diagnosed as IXT met the following criteria: (1) intermittent exotropia or constant exotropia at distance (the distance control assessment at baseline was performed three time and the average value ≥2 points); (2) intermittent exotropia, exophoria or orthophoria at near (the near control assessment at baseline was performed three times, at least one time ≤4 points); (3) ocular deviation measured using prism and alternate occlusion test was more than 15PD; (4) difference between the exodeviation at near and distance was less than 10PD (convergence insufficiency IXT was not included). Participants were not allowed to conduct nonsurgical management within 6 months before enrollment. Besides, refractive correction was performed if necessary. Appropriate glasses correction was worn for at least one week before enrollment.

### Enrollment Tests

Patients underwent a complete set of ophthalmic evaluation before enrollment. Exodeviation control ability was measured at distance (6m) and near (33cm) using 6-point office control score (Table 1), [8,9] which ranked from 0 (best control) ~ 5 (worst control). Control score was measured three times within one day because of its large variability. Stereoacuity at 40cm was measured using Titmus stereo test.

### Treatment Regimens

Participants were randomly divided into three groups which were patching, pencil push-up and observation. Examination sessions were conducted in a blind way.

Part-time patching: For IXT with equal dominance, eyes were covered alternately for 12 weeks, and 2 hours every day. For IXT with dominant eye, the dominant eye was covered for 4 days and non-dominant eye for 3 days per week, and the practice continued for 12 weeks. If the eye dominance status changed, our cover strategy would be readjusted.

Pencil push-up training: the pencil was raised at one arm’s distance between two eyes. An index card was put on the wall 6-8 feet away from the subject to control suppression. Patients were asked to look at the pencil tip, and tried to see it as single while moving tip of the pencil towards their noses. If one index card

on the wall disappeared from the view, the subject was instructed to stop moving the pencil and blinked eyes until two cards appeared again simultaneously. Patients continued to move the pencil slowly until it was seen as two, and then moved the pencil back into one. If the subjects couldn't keep the pencil tip single, they were told to repeat the above-described steps. All patients were trained 3 sets of 20 pencil push-ups daily, 5 days per week, for 12 weeks.

Observation: patients in the observation group did not receive any intervention except refractive correction.

### Follow-up Visits

Patients were followed up for 12 weeks. The compliance for training and occlusion was assessed after discussing with the parents, and by reviewing study calendars on which parents recorded the numbers of hours the child patched and training each day. Compliance was judged to be excellent (training or covering time> 75%), good (51% ~75%), fair (26% ~50%), or poor (25%). Control scores and stereopsis at 40cm were then evaluated. Stereopsis became a continuous variable by converting the seconds of arc scores to log arc/sec values, for example, 40 (1.60), 50 (1.70), 60 (1.78), 80 (1.90), 100 (2.00) and 200 (2.30). Stereopsis threshold doubled (e.g. 100 to 200 arc/sec) with 0.3 change in log transformed value.

During the 12-week visits, patching compliance was observed to be excellent in 15 patients (54%), good in eight patients (29%), fair in four patients (14%) and poor in one patient (4%). Pencil push-up training compliance was observed to be excellent in 17 patients (57%), good in seven patients (23%), fair in three patients (10%) and poor in two patients (7%), and was unknown in one patient (3%).

Throughout the follow-up period, unilateral patching was prescribed in eight participants (29%), alternate patching in 18 participants (64%), and both alternate and unilateral patching at different follow-up periods in two participants (7%).

### Statistical analysis

Data collected was normally distributed and was analyzed using SPSS 19.0. Paired t-test was used to compare deviation control before and after intervention. Chi-square test or Fisher's exact test was used to compare counting data. One-way ANOVA followed by post hoc tests was used to compare measurement data. A p-value less than 0.05 was considered as having statistical significance.

## Results

A total of 108 patients were eligible for the trail. Among them, 92 patients (28 in patching, 30 in pencil push-up and 34 in observation group) completed the follow up period. Poor adherence to patching or pencil push-up regimen and loss to follow-up were the main reasons for dropout. There were 45 male patients and 57 female patients and the average age was 5.23±1.66 years (3-15 years). Thirty-six participants had significant fixation dominancy. Being informed by their parents, 27 patients had photophobia. The best corrected visual acuity (BCVA) for all cases was 10/10, and corrective lenses were

worn by 16 subjects. Basic information of patient data are provided in Table 2 and Table 3. No significant difference of the baseline values were observed among the three groups.

## Control

The distance control improved significantly in the intervention groups. It decreased from 2.8±1.1 points to 1.6±1.0 points (P<0.001) in the alternate occlusion group and 3.1±1.1 to 2.0±1.5 (P=0.002) in the pencil push-ups group. There was no significant improvement in the observation group (2.8±0.9 points VS. 2.6±1.4 points; P=0.486).

A comparison of the mean values at the end of treatment demonstrated a significant difference among the three groups (P=0.013). Post hoc testing revealed that the mean distance control for the alternate occlusion group and pencil push-ups group was significantly greater than the mean of observation group (P=0.002; p=0.026). There was no significant difference when comparing alternate occlusion group with pencil push-ups group (P=0.134) (Table 4).

Furthermore, the means of control changes in the alternate occlusion group and pencil push-ups group were larger than that of the observation group before and after training (p<0.001; P=0.003). However, no significant difference was observed between the alternate occlusion group and pencil push-ups group (p=0.720) (Table 4).

Twelve-week distance control improved one point from baseline in 17 participants (61%) in the alternate occlusion group, 20 participants (67%) in the pencil push-ups group, and 12 participants (35%) in the observation group (P=0.027). Alternate occlusion group and pencil push-up group exhibited a better control improvement than observation group (p=0.010; P=0.012). No notable difference was observed between two treatment groups (p=0.637) (Table 3).

The distance control had more improvement in participants with poorer distance control before treatment. There were suggestions that the posterior treatment difference magnitude (favoring alternate occlusion and pencil push-ups treatment) was greater in subjects with poorer distance control at baseline (Table 5 and Table 6).

There was no difference among three groups in respect of the 12-week control at near (Table 4).

## Stereopsis

Eighty-eight patients cooperated for stereo acuity examination (27 in patching, 29 in pencil push-up and 32 in observation group). Means of log arc/sec at baseline were 1.85 ± 0.32 in the alternate occlusion group, 1.76±0.28 in the pencil push-ups group and 1.88±0.34 in the observation group; after the 12-week treatment they were 1.72 ± 0.12, 1.69±0.09 and 1.75±0.14, respectively. There was no significant difference among three groups after treatment (P=0.140). Also, no significant difference was found among the three groups in the difference values of stereoacuity before and after training (P=0.393).

# Discussion

The primary curative treatment for intermittent exotropia is surgery. Surgery may carry a risk of complications, such as overcorrection, undercorrection, the formation of amblyopia and the loss of stereopsis.[10-12] Non-surgical treatments for intermittent exotropia has been studied in many researches, yet controversy exists in regard to the optimum conservative therapy for IXT.[13]

Control ability is an important parameter reflecting the severity of IXT, which is more important than the angle of deviation. [14] Control usually refers to the frequency of manifest deviation and the ease of realignment. The six-point office control scale is used to quantify the control ability. A study performed by Buck et al. has shown that the distribution of the median NCS score at follow-up was unchanged, indicating that NCS was a better marker of progression of IXT. [14] And to reduce the influence of subjectivity on test results, the measurements of control were repeated three times and averaged.[15] In 2004, Haggerty et al defined the threshold of surgical intervention for IXT as the NCS≥3. Conservative treatment could improve the control ability. [16-19]

Occlusion is a well-known therapy to treat IXT by eliminating suppression and ensuring maximum reservations of binocular vision. It is suggested that occlusion interventions could decrease the size of suppression scotoma and turn exotropia into exophoria by reducing the squint.[20-22] Suppression is an active, progressive phenomenon. To avoid diplopia, images from the exotropic eyes would be ignored by our brain during the exotropia period. Therefore, occlusion eradicates suppression by removing the stimulus of the retina from external environmental signals, which in turn will improve eye position control.[3] Some researchers considered it to be a useful approach for younger children and patients who wish to delay surgery. The purpose of pencil push-up training is to mobilize the patient's autonomic convergence to overcome the deviation caused by fatigue or neurological instability. With no extra cost, both methodologies are easy to perform. A direct comparison of the occlusion therapy to push-up training was not performed.

According to the results of the office control 6-point scale, we found that far deviation control in patients with IXT who were between 5 and 7 years of age improved significantly over 12-week periods in both alternate occlusion group and pencil push-ups group. No improvement was observed in observation group. It is better to have observation combined with other interventions as an assessment method rather than applying it as a single treatment option.

Coffey et al. reported the pooled success rate of each non-surgical treatment modality based on the review containing 59 studies[23], of which the success rate of occlusion treatment was 37% (N=170), 28% (N=201) for prism treatment , 28% (N=215) for over-minus lens therapy and 59% (N=740) for orthoptic vision treatment; the success rates of surgeries depending on function or appearance were 43% and 61%. But the pooled results are debatable as studies included had limitations, such as selection bias, small sample sizes, inappropriate statistical analysis and insufficient criteria for success. These problems

indicate the need for a well-controlled study on the efficacy of different treatment modalities in controlling IXT.

Pediatric Eye Disease Investigator Group reported little deterioration over 6 months in all untreated childhood IXT, with or without patching therapy. Although patching group had a slightly lower deterioration rate.[19]A randomized clinical trial conducted by Mohammad Reza Akbari suggested that patients with IXT in the range of 3-8 years old may obtain a better treatment outcomes in comparison with observation.[24]

The Pediatric Eye Researchers Group (PEDIG) explored another application of part-time occlusion in the treatment of intermittent exotropia.[17,19] They examined the effect of patching on preventing deterioration in patients with better control, but not the effect to improve control in poorly controlled patients. Having constant exotropia progressed from intermittent for 6 months is considered as the criterion for deterioration. Studies show that most IXT diagnosed patients do not need treatment within a year.[25,26] Therefore, it is not surprising that the rate of deterioration in both groups was very low. Differences between groups were not statistically significant. PEDIG studies have not shown the effectiveness of occlusion therapy in improving control.

Pencil push-up is easy to learn and operate. It had a considerable effect on the treatment of undercorrection after intermittent exotropia surgery. Many investigators merely mentioned that pencil push-up was part of their routine for binocular vision training, without specifically reporting or investigating the effect of pencil push-up on control. The study found that both pencil push-up and occlusion could improve the control. They had similar therapeutic efficacy, and could be alternative conservative treatments for intermittent exotropia.

In addition to our primary outcome, we also evaluated the near stereoacuity in 12-week treatment. Aligned with the previous researches, no substantial improvement was found in sensory fusion after patching and pencil push-up. Distance stereoacuity function losses at the earliest stage of IXT progression. Meanwhile, the control level and stereoacuity at near is relatively stable, which may experience varying levels of stereoacuity loss in advanced stages. It is not difficult to understand that 12 weeks of patching and pencil push-up treatments did not promote the stereopsis at near significantly. Therefore, further research with longer follow-up periods is needed.

It is controversial to define deterioration of intermittent exotropia based on a decrease in stereoacuity at near. Holmes et al. reported that 6 out of 95 children (7%) for whom no treatment showed a reduction of 2 octaves in a single measurement of near stereoacuity, and 4 children in the future showed a regress to the baseline level of stereoacuity, emphasizing the need for retesting at the same or subsequent visits.[27] Since our current study requires that the stereoacuity test be retaken on the same day, some patients classified as deteriorating may have poor results due to feeling uncomfortable or uncooperative that day or the inherent variability of IXT. Nonetheless, due to the small decrease in stereoacuity in the two treatment groups (3.6% and 0.6%), any overestimated deterioration of stereoacuity due to not requiring a

retest on the next day will be minimal. In addition, any small overestimation of the deterioration is unlikely to affect the comparison of the treatment groups, considering that there is no difference in stereoacuity changes in the treatment groups. It is expected that the deterioration of the two groups will be overestimated by the same amount.

Based on the basic distance control, a secondary analysis was conducted to evaluate the effectiveness of occlusion and pencil push-up. It is noteworthy that the improvement of distance control is more evident for children with lower baseline distance control than those with better distance control. The larger response in children with poor baseline control may be partly due to a return to the average and having a lot of room for improvement. Yet, the same response level was not observed in the observation group, showing that this greater effect of occlusion and pencil push-up on children with poorer control may be real. However, due to the small sample size of the subgroup, this conclusion needs to be interpreted with care.

# Abbreviations

**IXT:** Intermittent exotropia

**PD:** Prism diopter

**NCS:** Newcastle Control Score

**PEDIG:** The Pediatric Eye Researchers Group

# Declarations


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Not Applicable.

### Funding

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### Authors' contributions

SDS contributed to study design and coordination, conducted the data analysis, and assisted in drafting and revising the manuscript. QJ was involved in data acquisition, data interpretation, and critical revision of the manuscript. CZJ helped to interpret the data and to draft and revise the manuscript. All authors have given final approval of the version to be published.

### Ethics approval and consent to participate

We adhered to the tenets of the Declaration of Helsinki. Ethics approval was obtained from the the ethics committee of Children's Hospital of Nanjing Medical University. All participants involved were informed of the purpose of this study and a written consent was obtained from themselves.

### Consent for publication

Not applicable

### Competing interests

The authors declare that they have no competing interests.

### Availability of data and materials

The data that support the findings of this study are available on request from the corresponding author SDS

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# Tables

Table 1. Exotropia Control Assessment Procedure

| Control | Score |
|---|---|
| constant exotropia | 5 |
| exotropia >50% of the 30-seconds period before dissociation | 4 |
| exotropia≤50% of the 30-seconds period before dissociation | 3 |
| no exotropia unless dissociated, recovers in >5 seconds | 2 |
| no exotropia unless dissociated, recovers in 1-5 seconds | 1 |
| no exotropia unless dissociated, recovers in≤1 second (phoria) | 0 |

Table 2. Demographic characteristics of patients

| Variables | Patch（n=28） | Pencil push-up（n=30） | Observation（n=34） | *P*-value |
|---|---|---|---|---|
| Age(mean±SD) | 5.45±1.45 | 5.24±1.42 | 5.66±1.37 | 0.482[a] |
| Sex(male:female) | 16:12 | 14:16 | 15:19 | 0.767[b] |
| Spherical equivalent (mean±SD) | 1.14±0.55 | 1.08±0.98 | 1.12±0.87 | 0.552 [a] |
| Significant dominancy (%) | 10(36) | 8(27) | 12(35) | 0.407 [b] |
| photophobia (%) | 8(29) | 10(33) | 9(26) | 0.377 [b] |

[a]Based on *t* test

[b]Based on the chi-square test

Table 3. Baseline Exotropia Control by Treatment Group

| | Distance control | | | Near control | | |
|---|---|---|---|---|---|---|
| | G1(28) | G2(30) | G3(34) | G1(28) | G2(30) | G3(34) |
| | N(%) | N(%) | N(%) | N(%) | N(%) | N(%) |
| control | | | | | | |
| 0 | 0 | 0 | 0 | 5(18) | 7(23) | 11(32) |
| 1 | 0 | 0 | 0 | 10(36) | 12(40) | 9(26) |
| 2 | 16(57) | 12(40) | 16(47) | 9(32) | 6(20) | 6(18) |
| 3 | 4(14) | 7(23) | 12(35) | 1(4) | 2(7) | 4(12) |
| 4 | 5(18) | 7(23) | 3(9) | 2(7) | 1(3) | 2(6) |
| 5 | 3(11) | 4(13) | 3(9) | 1(4) | 2(7) | 2(6) |
| Mean(SD) | 2.8(1.1) | 3.1(1.1) | 2.8(0.9) | 1.6(0.2) | 1.5(0.3) | 1.5(0.5) |

G1: alternate occlusion group; G2: pencil push-ups group; G3: observation group.

Table 4. Exotropia Control at 12-Week Outcome (Average of 3 Measurements)

| | Distance control | | | Near control | | |
|---|---|---|---|---|---|---|
| | G1(28) | G2(30) | G3(34) | G1(28) | G2(30) | G3(34) |
| | N(%) | N(%) | N(%) | N(%) | N(%) | N(%) |
| control | | | | | | |
| 0 | 1(4) | 4(13) | 1(3) | 8(43) | 8(50) | 10(24) |
| 1 | 15(54) | 11(37) | 7(21) | 11(29) | 14(27) | 8(21) |
| 2 | 7(25) | 6(20) | 11(32) | 8(21) | 4(13) | 7(21) |
| 3 | 4(14) | 2(7) | 4(12) | 1(4) | 2(3) | 5(15) |
| 4 | 0 | 5(17) | 7(21) | 0 | 1(3) | 2(12) |
| 5 | 1(4) | 2(7) | 4(12) | 0 | 1(3) | 2(9) |
| Mean(SD) | 1.6(1.0) | 2.0(1.0) | 2.6(1.1) | 1.0(0.2) | 1.2(0.2) | 1.6(0.3) |
| Change from baseline to 12weeks (points) | | | | | | |
| Mean(SD) | -1.2(0.9) | -1.1(1.2) | -0.2(1.1) | -0.6(0.2) | -0.3(0.1) | 0.1(0.2 ) |
| Improved 1 point | 17(61%) | 20(67%) | 12(35%) | 4(25%) | 4(27%) | 2(12%) |

G1: alternate occlusion group; G2: pencil push-ups group; G3: observation group.

Table 5. Change in Control from baseline to 12 Weeks according to baseline distance control

| Baseline Distance Control Score (Points) | Change in Control from Baseline to 12 Weeks (Points) | | | | | |
|---|---|---|---|---|---|---|
| | G1(28) | | G2(30) | | G3(34) | |
| | N | Mean | N | Mean | N | Mean |
| 2-<3 | 16 | -0.5 | 12 | -0.6 | 16 | 0.1 |
| 3-<4 | 4 | -0.8 | 7 | -0.9 | 12 | -0.4 |
| 4-5 | 8 | -2.4 | 11 | -2.3 | 6 | -0.9 |

G1: alternate occlusion group; G2: pencil push-ups group; G3: observation group.

N: The total number of subjects; Mean: the means of distance control score changes

Table 6. Treatment response at 12 Weeks

| Baseline Distance Control Score (Points) | Treatment Response at 12 Weeks(Control Improved ⩾1 Point) | | | | | |
|---|---|---|---|---|---|---|
| | G1(28) | | G2(30) | | G3(34) | |
| | N | n(%) | N | n(%) | N | n(%) |
| 2-<3 | 16 | 8(50) | 12 | 6(50) | 16 | 4(25) |
| 3-<4 | 4 | 2(50) | 7 | 5(71) | 12 | 6(50) |
| 4-5 | 8 | 7(87) | 11 | 9(82) | 6 | 2(33) |

G1: alternate occlusion group; G2: pencil push-ups group; G3: observation group.

N: The total number of subjects; n:the number of patients whose distance control

score increased by one point.