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Surgical outcomes after preoperative prism adaptation in patients with partially accommodative esotropia

부분조절내사시 환자에서 프리즘적응검사 후 수술결과 분석

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Surgical outcomes after preoperative prism adaptation in patients with partially accommodative esotropia

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Purpose: To assess the surgical results after prism adaptation test in individuals with partially accommodative esotropia (PAET)
Methods: The medical records of 51 patients with PAET who were managed surgically at single referral center were retrospectively reviewed. Patients were divided into two groups depending on whether or not they took the prism adaptation test. Data about sex, age, initial angle of deviation, final angle of deviation, stereoacuity, surgical dosage, and postoperative follow-up periods were collected. The main outcome of this study was motor outcomes at 1 year after surgery. Outcomes at last visit were also analyzed.
Results: Eighteen patients had a history of prism adaptation (PA group) and 33 did not (augmented surgery group, AS group). One year after surgery, 12 (66.7%) patients in the PA group and 21 (63.6%) in the AS group achieved an angle of deviation less than 5 PD. The surgical success rate in both groups did not significantly differ ($p = 1$). After the first prism adaptation test, six patients had an angle of deviation similar to the previous angle; however, 12 patients had larger angle, and consequently required additional prism (prism builder). Two (33.3%) patients who were prism non-builders had deviation less than 5 PD during the last visit. However, among the prism builders, four (57.1%) and five (100%) patients who were single and multiple prism builders, respectively, had less than 5 PD deviation during the last visit ($p = 0.03$).
Conclusion: No significant differences were observed in terms of surgical outcomes between both groups. Nonetheless, in PA group, prism builders have better surgical outcomes than non-builders.

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Keywords: partially accommodative esotropia; prism adaptation; surgical outcomes; augmented surgery
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목 차

표 목차

Introduction

The surgical target angle in patients with partially accommodative esotropia (PAET) is challenging to identify. Prism adaptation and augmented surgery are methods used to improve surgical outcomes.[1, 2] In the prism adaptation study (PAS) research group, prism adaptation significantly improves motor outcome at 1 year after esotropia surgery in prism responders, and the number of overcorrections does not increase.[3, 4]

By contrast, previous studies have shown a lower incidence of undercorrections in augmented surgery than in conventional surgery. However, augmented surgery always has a risk for overcorrections due to its uncertainty.[2, 5] In addition, there is no standard augmented surgery. Hwang et al. have conducted a randomized controlled study to compare the effect of prism adaptation and augmented surgery on esotropia associated with hypermetropia.[6] Result has revealed no significant differences in terms of surgical outcomes between the study groups.

Although several studies have been conducted to assess the increased surgical success rate of PAET, a standardized method has still not been established, and whether one method is superior to the other has been controversial.

Therefore, this study aimed to retrospectively evaluate the surgical outcomes after prism adaptation in patients with PAET and identify the characteristics of patients who got an advantage from the prism adaptation test.

Materials and Methods

The procedures used in this study were in accordance to the Declaration of Helsinki and were approved by the Institutional Review Board of Seoul National University Hospital.

The medical records of patients with PAET who underwent surgery at Seoul National University Children's Hospital between June 1, 2011, and June 30, 2018 were retrospectively reviewed. PAET was diagnosed in those patients with an acquired esotropia that was reduced after wearing hyperopic spectacles full time, but a residual deviation of 10 PD or more.[7] Moreover, patients with amblyopia, and anisometropia were included after adequate management of their underlying situations. Among them, consecutive patients were included in this study if they were followed up for more than 1 year postoperatively. Meanwhile, patients with extraocular muscle palsy, any vertical strabismus, or combined neurologic diseases were

excluded. Patients with a high accommodative convergence/accommodation (AC/A) ratio esotropia, who required bifocal glasses, were also excluded. All participants underwent a complete ophthalmologic examination during the preoperative period. A single ophthalmologist (S-J K.) performed simultaneous prism cover test (SPCT) with a fixation target at 1/3 and 5 m during each visit. Each patient wore glasses for cycloplegic refraction before surgery. The prism adaptation test were started in all patients with PAET who seemed to require surgical correction after February 2014; before, all the patients had undergone augmented surgery instead of the prism adaptation test. A single surgeon (S-J K) performed all surgical procedures while the patients were under general anesthesia. All patients underwent recessions of the unilateral or bilateral medial recti.

Prism adaptation group (PA group)

The patients started to receive press-on prisms according to the amount of distant deviation. They were followed-up for 30-45 days. If they presented with esotropia that is more than 8 PD after prismatic correction, more prisms were added, and further follow-up visits were conducted. Prism builder was defined as a patient requiring base-out prism adding procedure during their follow-ups.

If the patients had a stable status (orthotropia or esotropia that is less than 8 PD with press-on prisms), they recommended to discontinue the prism adaptation and schedule the operation. If the patients presented with gradually increasing esodeviation and it reached at the point that two times larger than the first deviation, the prism adaption was discontinued. Surgical corrections were performed for the distance deviation after prismatic correction.

Augmented surgery group (AS group)

For comparison with the prism adaptation group, patients with PAET who underwent surgery and who never had the prism adaptation test were assessed. The surgical dosage for augmented surgery was calculated as performing an additional 0.5 mm more than Augmented surgery group 25the surgical amount recommended by Parks based on the near deviation with refractive correction.[8]

Postoperative evaluation

Follow-up examinations of all the patients were scheduled at 1, 3, 6 months and 1 year after surgery. After 1 year, patients have diverse follow-up periods. A successful motor outcome was defined as a horizontal deviation less than or equal to 5 PD based on

SPCT. Sensory outcome was evaluated at least once after surgery randomly using the Worth 4-dot test and Titmus Fly Test. If a patient required a second surgery, it was considered to be a failure.

Statistical analysis

The primary outcome of this study is the success rate of each group at 1 year and at the last visit. Then a subgroup analysis was conducted on the PA group for identifying clinical characteristics of successful patients; thus, the patients in this group were further divided according to surgical success or failure. Also, prism builders were classified into three categories according to the number of prism add-up; prism non-builder, single prism builder, and multiple prism builder. Those subgroups were also analyzed. The Fisher's exact test and independent T test were mainly used to compare the results, while linear-by linear association and one-way ANOVA were used in the comparison of three groups. In the circumstance that needed a nonparametric test, Wilcoxon signed rank test and Kruskal-Wallis test were used. P-value less than or equal to 0.05 was considered statistically significant. Statistical analysis was performed using the Statistical Package for the Social Sciences software version 22.

Results

A total of 18 patients were included in the PA group and 33 in the AS group. The demographic characteristics of the patients in each group are presented in Table 1. Before the prism adaptation test, the PA and AS groups had similar distance–near disparity (5.30 ± 4.73 vs. 4.86 ± 5.97, p = 0.77). However, after the prism adaptation test, the gap between distance and near angle of deviation in the PA group was smaller than that in the AS group (1.80 ± 2.84 vs. 4.86 ± 5.97, p = 0.015). The PA group had larger esodeviation at the time of surgery than the AS group (30.00 ± 11.11 vs. 24.42 ± 8.00 PD, p = 0.07), even though they had a smaller amount of recession on average (8.25 ± 2.18 vs. 9.82 ± 1.55 mm, p = 0.015). Thus, the PA group was applied larger surgical dosage than the AS group was (3.77 ± 1.70 vs. 2.96 ± 0.73 PD/mm, p = 0.021).

Table 1. Demographics of the prism adaptation group and the augmented surgery group

	PA group (N=18)	AS group (N=33)	p-value
Gender (M:F)	10:8	16:17	0.7712
Age at first visit (month)	42.83±26.33	46.67±18.94	0.551
Age at surgery (month)	62.73±25.13	62.1±20.9	0.925
Preoperative follow-up periods (weeks)	85.66±61.53	65.94±74.96	0.318
Amblyopia	1/18	4/33	0.6446
BCVAs (logMAR)	0.21±0.16	0.04±0.20	0.167
Cycloplegic refractive errors (SE)	3.66±1.74	3.58±1.77	0.816
Anisometropia	1/18	2/33	1
Angle of deviation (distance, PD)	30.00±11.11	24.42±8.00	0.07
Angle of deivation (near, PD)	32.00±10.05	29.24±9.49	0.349
Distance-near disparity (PD)	1.80±2.84	4.86±5.97	0.015
Preoperative stereoaquity - under 3000 arcsec	9/13[a]	11/20[a]	0.4851
Preoperative stereoaquity - under 400 arcsec	3/13[a]	7/20[a]	0.7006
Preoperative stereoaquity - under 100 arcsec	0/13[a]	3/20[a]	0.2614
Amount of surgery (mm)	8.25±2.18	9.82±1.55	0.015
Surgical dosage (PD/mm)	3.77±1.70	2.96±0.73	0.021
Postoperative follow-up periods (weeks)	62.73±25.13	50.9±21.7	0.925

a. Statistics using the number of patients who were available for each test.

Abbreviations: AS = augmented surgery; PA = prism adaptation; PD = prism diopter; BCVAs = best corrected visual acuities; SE = spherical equivalent

One year after surgery, 12 (66.7%) patients in the PA group and 21 (63.6%) in the AS group met the criteria for surgical success (p = 1). Of the remaining patients, 6 (33.3%) in the PA group and 7 (21.2%) in the AS group had esotropia, and 5 (15.2%) patients in the AS group had exotropia for distance. None of the patients in the PA group presented with exotropia postoperatively. At the last visit, 11 (61.1%) in the PA group and 18 (54.5%) in the AS group showed successful motor outcomes (p = 0.770). Regarding sensory outcomes, the two groups did not significantly differ in terms of postoperative stereoacuity (2.55 ± 0.62 vs. 2.86 ± 0.58 log arcsec, p = 0.095) (Table 2).

Table 2. Surgical outcomes of the prism adaptation group and the augmented surgery group

	PA group (N=18)	AS group (N=33)	p-value
Motor outcomes at 1 year			0.356[b]
Success	12 (66.7 %)	21 (63.6 %)	1
Undercorrection	6 (33.3 %)	7 (21.2 %)	0.502
Overcorrection	0 (0.0 %)	5 (15.2 %)	0.148
Motor outcomes at last visit			0.227[b]
Success	11 (61.1 %)	18 (54.5 %)	0.770
Undercorrection	6 (33.3 %)	6 (18.2 %)	0.304
Overcorrection	1 (5.6 %)	9 (27.3 %)	0.077
Fusion response, near[a]	8/16 (50.0 %)[c]	17/28 (60.7 %)[c]	0.585
Fusion response, distance[a]	4/16 (25.0 %)[c]	7/28 (25.0 %)[c]	0.666
Stereoacuity (log arcsec)[a]	2.86±0.58[c]	2.55±0.62[c]	0.095
Improved stereoacuity [a]	7 (38.9 %)	12 (36.4 %)	0.454
Aggravated stereoacuity[a]	0 (0.0 %)	3 (9.1 %)	0.238

a. Sensory outcomes were evaluated at least once after surgery, and the highest score was used for statistical analysis.

b. linear-by-linear association

c. Statistics using the number of patients who were available for each test.

Abbreviations: AS = augmented surgery; PA = prism adaptation

The patients in the PA group were divided according to surgical success or failure one year after surgery and were compared (Table 3). The success group had larger amount of change in the prism glasses than the failure group (10.73 ± 7.39 vs. 4.00 ± 5.29 PD, p = 0.039). Moreover, patients who had a successful outcome had significantly smaller residual esotropia after prismatic

correction than those who did not (2.91 ± 3.18 vs. 6.57 ± 2.01 PD, p = 0.009). Otherwise, both groups did not differ in clinical characteristics.

Table 3. Subgroup analysis of the prism adaptation group by surgical outcomes

	Success group (N=11)	Failure group (N=7)	P-value
Gender (M:F)	6:5	4:3	1
Age at surgery (month)	55.7±16.3	73.7±33.4	0.222
Preoperative follow-up periods (weeks)	97.6±59.4	66.9±64.6	0.331
Entry deviation (distance, PD)	14.73±7.32	16.86±11.06	0.662
Entry deviation (near, PD)	18.27±7.66	25.29±9.67	0.134
Amount of prism add-up (PD)[a]	10.73±7.39	4.00±5.29	0.039
Residual deviation after prism adaptation (PD)	2.91±3.18	6.57±2.01	0.009
Deviation at surgery (distance, PD)	29.18±10.15	31.29±13.24	0.727
Deviation at surgery (near, PD)	30.64±8.86	34.14±12.12	0.523
Amblyopia	0/11	1/7	0.389
BCVAs (logMAR)	0.26±0.15	0.13±0.16	0.131
Cycloplegic refractive errors (SE)	3.44±1.81	3.99±1.70	0.527
Anisometropia	1/11	0/7	1
Preoperative fusion response, near	3/9[b]	2/4[b]	1
Preoperative fusion response, distance	1/9[b]	0/4[b]	1
Preoperative stereoacuity	9[b]	4[b]	
Under 100 arcsec	0	0	1

100 ~ 400 arcsec	2	1	1
400 ~ 3000 arcsec	4	2	1
Over 3000 arcsec	3	1	1
Amount of surgery	8.09±2.19	8.50±2.33	0.716
Surgical dosage (PD/mm)	3.82±1.92	3.68±1.32	0.859
Postoperative stereoacuity (log arcsec)	3.45±0.43[b]	3.41±0.56[b]	0.901
Improved stereoacuity	5/9[b]	2/4[b]	1
Aggravated stereoacuity	0/9[b]	0/4[b]	1
Postoperative follow-up periods (weeks)	33.02±13.58	40.32±17.67	0.372

a. The amount of change in the prisms from the first glasses to the final preoperative glasses.

b. Statistics using the number of patients who were available for each test.

Abbreviations: PD = prism diopter; BCVAs = best corrected visual acuities; SE = spherical equivalent

As the success group had significantly larger amount of prism add-up than the failure group, a subgroup analysis was conducted according to how many times they got add-up the prism glasses In all patients in the PA group, 6 were considered prism non-builders, 7 were single prism builders, and 5 were multiple prism builders. No difference was observed in surgical outcomes of 1-year follow up. However, in the results of last visit, prism builders showed better motor and sensory outcomes than prism non-builders did, and multiple builders were superior to single builders.(Table 4). Only two (33.3%) patients of non-builders had deviation less than 5 PD during the last visit. However, among the prism builders, four

(57.1%) and five (100%) patients who were single and multiple builders, respectively, had less than 5 PD deviation during the last visit (p = 0.03, linear-by-linear association). Four (66.7%) patients among the single builders and four (100%) among the multiple builders had fusional response at a near based on the Worth 4-dot test, and none of the non-builders presented with fusional vergence response (p = 0.005, linear-by-linear association).

Table 4. Subgroup analysis of the prism adaptation group by the number of prism add-up

	Non-builder (N=6)	Single builder (N=7)	Multiple builder (N=5)	p-value
Amount of prism add-up (PD) [a]	0.00±0.00	9.57±2.30	15.80±6.54	0.001
	0-1 (0.002)	0-2 (0.004)	1-2 (0.082)	
Preoperative stereoacuity	3[c]	5[c]	4[c]	
Under 100 arcsec	0	0	0	
100 ~ 400 arcsec	0	1	2	0.141
400 ~ 3000 arcsec	2	2	2	0.716
Over 3000 arcsec	1	2	1	0.797
Successful motor outcomes at 1 year	3	4	4	0.299
Successful motor outcomes	2	4	5	0.030

at last visit				
Postoperative stereoacuity (log arcsec)[b]	3.00± 0.63c	3.04± 0.74c	3.00± 0.00c	0.217
Improved stereoacuity [b]	1/4c	2/4c	4/5	0.112
Aggravated stereoacuity[b]	0/4c	0/4c	0/5	
Postoperative fusion response, near[b]	0/6	4/6c	4/4c	0.005
Postoperative fusion response, distance[b]	1/6	1/6c	2/4c	0.162
Postoperative follow−up periods (months)	43.00± 13.16	34.84± 18.08	29.20± 11.99	0.375

a. The amount of change in the prisms from the first glasses to the final preoperative glasses.

b. Sensory outcomes were evaluated at least once after surgery, and the highest score was used for statistical analysis.

c. Statistics using the number of patients who were available for each test.

Abbreviations: PD = prism diopter; BCVAs = best corrected visual acuities; SE = spherical equivalent

Discussion

In this retrospective review, 1-year surgical outcomes did not significantly differ between patients who underwent the prism adaptation test and augmentation surgery ($p = 0.356$, linear-by-linear association). 66.7% of patients in the PA group and 63.6% in the AS group met the criteria for a successful treatment ($p = 1$). Patients in the PA group were less likely to present overcorrection (0.0%) than those in the AS group (15.2%), but the result did not significantly differ ($p = 0.148$). Those outcomes remained similar at the last visit.

In this study, the distance-near disparity was decreased after prism adaptation. Previous studies revealed effect of prism adaptation in reducing distance-near disparity of esotropia,[17, 18] but few study clarified the mechanism. However, Burke stated that prism adaptation helped to determine the maximal change of the distance angle that can be tolerated by one's motor fusion.[19] Therefore, it could be assumed that prism adaptation might reduce the gap between distance and near deviation by increasing distance angle more.

According to the PAS research group, preoperative prism adaptation significantly improves motor outcome after the surgical

correction of acquired esotropia. Moreover, they reported that the 1-year success rate is 90%.[3, 4, 9]

Augmented surgery was introduced for the treatment of undercorrection, which is a problem of standard surgery; however, such procedure is known for its risk of overcorrection. Wright and Bruce-Lyle have reported that the use of the average near deviation with and without correction increases the surgical success rate of PAET to 88%, but it simultaneously increases the rate of overcorrection.[2] And Hwang et al. have shown that 85% of the patients in the augmented group, 89% of the prism responders, and 100% of the prism non-responders in the prism adaptation group had a successful surgery after 1 year, and none of the patients in the prism adaptation and augmented groups presented with overcorrection.[6, 10] However, in our study, the success rates were lower: 63.6% in the PA group and 60.0% in the AS group, and a high number of patients in the AS group (n = 5, 15.2%) had overcorrection, which might be attributed to the heterogeneity of this study group as including patients with distance-near disparity and amblyopia.

Furthermore, this study set a strict limit for surgical success compared with previous studies. Although there was no consensus

for the definition of good motor surgical outcome after PAET, most studies have shown that a deviation less than 8–10 PD indicates good motor outcome after surgery.[3, 6, 11–16] However, this study defined a deviation of 5 PD as the limit of surgical success because a deviation larger than that angle frequently causes sensory deprivation and psychosocial problems. If the margin for surgical success is changed to a deviation of 10 PD, the surgical success rate will increase to 80%–85%, which is similar to the success rate in previous studies.

Quigley et al. have reported that patients who required more than a 5–PD increase in base–out prism during the prism adaptation test have a better surgical success rate (100%) than those who did not (56%).[14] This study had similar results showing that prism builders presented with better surgical outcomes than prism non–builders (33.3% vs. 75.0%). In addition, if more prism glasses were added, the motor and sensory outcomes were better ($p = 0.030$).

Thus, prism builders are more likely to maintain their angle of deviation due to cortical connections. Wong et al. have revealed that in primates with small esotropia, neuronal linkages between ocular dominance columns (ODCs) were identified if the deviation was lower than 9 PD.[20] They insisted that this linkage explained the

solid angle of vergence misalignment observed in humans who have monofixation syndrome. Furthermore, Savino et al. have shown that the prism eating phenomenon in patients with monofixation syndrome may be attributed to the long-standing convergent position with rooted anomalous convergent movements, which increase the medial recti tonus.[21] Based on a similar context, it was assumed that prism builders might develop neuronal connections between non-adjacent ODCs, which cause them to prefer the specific angle of deviation. Therefore, this linkage made the capacity of fusional vergence as well as the stability of eye position, that the patients could maintain the good postoperative status instead of recurrence or overcorrection.

In this study, prism builder was defined as a patient with an esodeviation greater than or equal to 8 PD after the prism adaptation test. However, patients who had a smaller residual angle after prismatic correction had better surgical outcomes than those with larger residual angle (2.91 ± 3.18 vs. 6.57 ± 2.01, p = 0.009) (Table 3), and the average residual angle of patients who showed unsatisfied surgical outcomes was smaller than 8 PD. Therefore, future studies on the addition of prisms in patients with an angle deviation of less than 8 PD must be performed.

Our study showed the surgical outcomes of PAET patients who tried the prism adaptation test as a method for preoperative target angle determination. And such procedure was similar to augmented surgery in terms of success rate with less overcorrection. In addition, when patients showed distance-near disparity, the prism adaptation test could decrease the gap between distance and near angle of deviation. Thus, it could help surgeons to determine the accurate number of surgical correction. Furthermore, a gradually increasing angle of deviation despite of prism adaptation may indicate a good prognosis after surgery.

The present study had some limitations. First, it is a retrospective study and has a small sample size with heterogeneous patients. Moreover, after the 1-year follow-up visit, the patients had different follow-up periods, thereby making the comparison of long-term surgical outcomes challenging. Thus, further prospective, randomized studies must be performed to validate the findings of this study.

In conclusion, the two groups in this study did not significantly differ in terms of success rates. However, the prism adaptation test might reduce the risk of overcorrection compared with augmented surgery, and that prism builders, defined as patients who had

gradually increasing esotropia with the prism adaptation test, may have a good prognosis after surgery.

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부분조절내사시 환자에서 프리즘적응검사 후 수술결과 분석

목적: 부분조절내사시 환자에게 수술 전 프리즘적응검사 시행 후 이에 따라 수술을 진행했을 때 수술결과가 어떠한지 분석하고자 하였다.

방법: 2011년 6월부터 2018년 6월까지 서울대학교 어린이병원에서 부분조절내사시로 수술 받은 환아들을 대상으로 후향적 의무기록 분석을 시행하였다. 또한, 수술 전 프레넬프리즘을 이용한 프리즘적응검사를 시행한 환자와 프리즘적응검사를 하지 않고 증량수술한 환자를 각각 프리즘적응군과 증량수술군으로 설정하여 두 군의 수술 결과를 비교하였다. 환자의 성별, 나이, 프리즘적응검사 전 사시각, 수술시점의 사시각, 입체시, 수술량, 수술 후 경과관찰 기간 등의 정보를 수집하였다. 수술 후 1년째 및 최종 외래 방문 시 수술결과에 대해 분석하였다.

결과: 프리즘적응군 18명, 증량수술군 33명이 포함되었다. 수술 1년 후 결과를 비교했을 때 프리즘적응군에서 12명(66.7 %), 대조군에서 21명(63.6 %) 성공률을 보였다(p = 1). 또한 프리즘적응검사 당시 6명은 사시각이 커지지 않았지만, 12명은 처음과 비교하여 사시각이 커져서 프리즘 증량이 필요했다. 프리즘 증량을 하지 않은 환자 중 2명(33.3 %)만이 최종 경과관찰에서 성공적인 결과를 보인데 반해, 프리즘을 한 번 증량했던 환자 중에서는 4명(57.1 %), 두 번 이상 증량했던 환자 중에서는 5명(100 %)이 성공적인 결과를 보였다(p = 0.03).

결론: 부분조절내사시 환자에서 수술 전 프리즘적응검사를 시행하는 것은 증량수술과 비교하여 수술 결과에 유의한 차이를 주지 않았으나, 프리즘적응검사에서 꾸준히 각이 커졌던 환자들은 그렇지 않은 환자에 비해 좋은 예후를 보였다.

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주요어: 부분조절내사시, 프리즘적응검사, 증량수술, 수술결과
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