Time and Factors Affecting the Direction of Re-drift in Essential Infantile Esotropia

Kun-Hoo Na, MD; Yoonae A. Cho, MD, PhD; Seung-Hyun Kim, MD, PhD

ABSTRACT

Purpose: To investigate the development pattern and related factors of postoperative re-drift in infantile esotropia.

Methods: A total of 112 patients with infantile esotropia who underwent surgery before 3 years of age were included. Surgical outcomes were divided into (1) consecutive exotropia: more than 8 prism diopters (PD) of exodeviation; (2) recurrent esotropia: more than 8 PD of esodeviation; and (3) monofixation syndrome: maintenance of deviations within 8 PD. The occurrence rate, time of onset, and associated factors of the re-drift were evaluated.

Results: At a mean follow-up of 9.5 years, consecutive exotropia developed in 37 patients (33.0%) and recurrent esotropia in 43 patients (38.4%). Whereas 76.7% of total recurrent esotropia cases were identified within postoperative 1 year, consecutive exotropia occurred constantly over 10 years postoperatively. The mean time to consecutive exotropia development from surgery was 78.6 months, greater than that of recurrent esotropia development (8.9 months) \((P < 0.001)\). In multinomial logistic regression using monofixation syndrome as the reference category, fixation preference before surgery (odds ratio [OR]: 6.64, 95% confidence interval [CI]: 2.07 to 21.32) and the rate of myopic progression (OR: 15.07 per \(-1.00\) D/year, 95% CI: 1.23 to 184.86) were associated with consecutive exotropia, whereas increase in the angle of esodeviation on postoperative day 1 (OR: 1.15, 95% CI: 1.04 to 1.26) was correlated with recurrent esotropia.

Conclusions: This study demonstrates a difference between the development pattern of exotropic and esotropic drift after infantile esotropia surgery. Detailed preoperative assessment and close postoperative observation of deviations and refractive status will help to determine surgical outcomes of infantile esotropia.

INTRODUCTION

Although exotropic or esotropic drift after surgical correction for infantile esotropia has been reported to be common, the onset time and factors of the re-drift have not been well studied.

Recurrence after infantile esotropia surgery was reported to occur at various postoperative periods.\(^1,2\) Although the onset of overcorrection after esotropia surgery was also reported to be variable, several studies suggested a long latency period before the development of overcorrection.\(^1,3,4\) In a previous study, the time interval between original surgery and reoperation for overcorrection was reported to be up to 47.5 years.\(^5\)

There have been several studies evaluating factors correlated with re-drift after infantile esotropia surgery. The proposed factors for recurrence included an accommodative component\(^6\) and large preoperative esodeviation,\(^1\) whereas multiple surgeries,\(^7\) postoperative adduction deficit,\(^7,8\) and conditions associated with poor fusional status\(^9,10\) were reported to be associated with overcorrection.
There has never been a report comparing the development pattern between recurrence and overcorrection and evaluating potential factors affecting the direction of re-drift in surgically corrected patients with infantile esotropia in a single study. This study aimed to investigate the rate and onset of the development of re-drift after infantile esotropia surgery and to identify associated factors of the re-drift.

**PATIENTS AND METHODS**

The medical records of patients with infantile esotropia who underwent surgery before 3 years of age between 1985 and 2008 were retrospectively reviewed. Infantile esotropia was defined as 30 prism diopters (PD) or greater of esodeviation noted within the first 6 months of life without neurological disorders or developmental delay. The minimum required follow-up duration after surgery was 5 years. Patients with hyperopia greater than +3.00 diopters (D) in cycloplegic refraction, history of strabismus surgery, paralytic or restrictive strabismus, and other ocular diseases including retinopathy of prematurity were excluded. Patients who demonstrated deviation of more than 8 PD at postoperative day 1 were also excluded to avoid bias against the effects of inappropriate surgical dosage. Approval from the institutional ethics review board of Korea University Medical Center was obtained and the study was conducted in full accordance with the tenets of the Declaration of Helsinki.

**Preoperative Examination**

Preoperative ophthalmologic examinations included measurement of the angle of deviation with the prism and alternate cover test at distance (6 m) and near (1/3 m) fixation, and motor functions including version and duction, checking for the association of dissociated vertical deviation (DVD) and inferior oblique muscle overaction (IOOA), evaluation for the presence of fixation preference, manifest and cycloplegic refraction using retinoscopy, and a fundus examination. Patient characteristics including sex, age at surgery, and duration of esotropia were identified.

**Surgical Interventions**

All surgeries were performed under general anesthesia by a single experienced surgeon (YAC). Bilateral medial rectus recession (BMR) was performed for esodeviation up to 70 PD. If the preoperative angle was between 45 and 70 PD, BMR alone or in combination with a unilateral lateral rectus resection was conducted. For deviation of 75 to 80 PD, BMR was combined with resections of both lateral rectus muscles. The surgical formula is demonstrated in Table 1. Patients with fixation preference at baseline examination had occlusion treatment before surgery until they showed alternate fixation or no improvement was confirmed.

**Postoperative Assessment**

Postoperative alignment in primary position was assessed at the 1-day and 1-, 3-, 6-, and 12-month postoperative visits, and annually thereafter. Surgical outcomes were divided into three categories according to the degree of postoperative deviation at distance. Exodeviation of more than 8 PD was defined as consecutive exotropia, and esodeviation of more than 8 PD was defined as recurrent esotropia. Because patients without the development of consecutive exotropia or recurrent esotropia maintained stable ocular alignment within 8 PD over a long postoperative period (an average 10 years as demonstrated on Table 2), and they also demonstrated 8 PD or less on the simultaneous prism cover tests performed during follow-up, we defined these patients as the monofixation syndrome group. Reoperation was indicated if exodeviation greater than 15 PD or esodeviation greater than 10 PD persisted or increased for 6 months despite non-surgical management such as occlusion treatment or spectacle correction of refractive errors. The development of DVD, IOOA, and adduction limitation were monitored during the observation period. Manifest refraction with retinoscopy was performed at each postoperative visit to evaluate refractive error status. Stereoacuity was assessed with the Titmus test (Stereo Optical Co., Inc., Chicago, IL) for cooperative patients. Stereoacuity of 200 arc seconds or less was defined as favorable stereopsis and 400 to 3,000 arc seconds as fair stereopsis.

**Statistical Analysis**

Baseline characteristics, the degree of deviation angle at postoperative day 1, the annual rates of myopic progression based on the results of manifest refractions during 5 years after surgery, the rate of postoperative development of DVD, IOOA, and
adduction deficit, and the results of the Titmus test were compared between the consecutive exotropia, recurrent esotropia, and monofixation syndrome groups. One-way analysis of variance was used for continuous variables. Associations between qualitative variables were evaluated using the chi-square test or the Fisher’s exact test.

Based on Kaplan–Meier analysis, cumulative rates of the development of re-drift were evaluated and time to re-drift outcomes were compared with the log-rank test. The rates of reoperation due to the re-drift were also evaluated.

Multinomial logistic regression, using monofixation syndrome as the reference category, was used to determine the factors associated with the development of re-drift. Variables for analysis included age at surgery, duration of esotropia, sex, preoperative angle of deviation, preoperative refractive error, fixation preference before surgery, presence of DVD and IOOA, type of surgery, angle of deviation at postoperative day 1, and the annual rate of myopic progression. A P value of less than .05 was considered statistically significant.

**RESULTS**

A total of 112 patients with infantile esotropia were included with a mean of 9.5 years of postoperative follow-up. Among them, consecutive exotropia developed in 37 patients (33%) and recurrent esotropia in 43 patients (38.4%). Thirty-two patients (28.6%) maintained deviation within 8 PD during the postoperative period and were assigned to the monofixation syndrome group. The proportion of patients with fixation preference was the only preoperative parameter showing a difference between the groups (P < .001). The distribution of the surgical methods was comparable among the groups (P > .05) (Table 2). At postoperative day 1, the recurrent esotropia group demonstrated a mean 2.2 PD of esodeviation, whereas the consecutive exotropia and monofixation syndrome groups showed 3.3 and 2.4 PD of exodeviation on average, respectively (P = .002 for recurrent esotropia vs consecutive exotropia, P = .017 for recurrent esotropia vs monofixation syndrome, one-way analysis of variance with Bonferroni’s correction). The annual rate of myopic progression was the highest in the consecutive exotropia

<table>
<thead>
<tr>
<th>Deviation (PD)</th>
<th>BMR (mm)</th>
<th>Three-Muscle Surgery (mm)</th>
<th>Four-Muscle Surgery (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>5.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>5.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>5.5 to 6.0</td>
<td>BMR 4.0, ULR 5.0</td>
<td>BMR 5.0, ULR 3.0</td>
</tr>
<tr>
<td>50</td>
<td>6.0</td>
<td>BMR 4.0, ULR 6.0</td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>6.0 to 6.5</td>
<td>BMR 5.0, ULR 5.0</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>6.5</td>
<td>BMR 5.0, ULR 6.0</td>
<td></td>
</tr>
<tr>
<td>65</td>
<td>6.5 to 7.0</td>
<td>BMR 5.0, ULR 7.0</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>7.0</td>
<td>BMR 5.0, ULR 8.0</td>
<td></td>
</tr>
<tr>
<td>75</td>
<td></td>
<td>BMR 5.0 to 5.5, BLR 6.0</td>
<td></td>
</tr>
<tr>
<td>80</td>
<td></td>
<td>BMR 5.0 to 5.5, BLR 6.5</td>
<td></td>
</tr>
</tbody>
</table>

PD = prism diopters; BMR = bilateral medial rectus recession; ULR = unilateral lateral rectus resection; BLR = bilateral lateral rectus resection
The cumulative rates of the development of re-drift over time are represented in Figure 1. The average time from surgery to onset of re-drift was 78.6 ± 8.8 months in the consecutive exotropia group, which was greater than that of the recurrent esotropia group (8.9 ± 1.9 months; P < .001, log-rank test). Recurrent esotropia occurred mostly in the early postoperative period and the cumulative rate of recurrent esotropia was 29.5% up to postoperative 1 year, which accounted for 76.7% of the total recurrent esotropia occurrence. The remaining recurrent esotropia cases occurred during the next 4-year period from 1 to 5 years postoperatively. In contrast, because consecutive exotropia occurred constantly over 10 years postoperatively, the cumulative rate of consecutive exotropia development increased in a linear fashion. The number of patients undergoing reoperation was 27 (73.0%) in the consecutive exotropia group and 28 (65.1%) in the recurrent esotropia group (P > .05).

In the multinomial logistic regression analysis, we found significant correlation of the fixation preference before surgery (odds ratio [OR]: 6.64, 95% confidence interval [CI]: 2.07 to 21.32) and a greater rate of myo-

**Figure 1.** The cumulative rates of the development of postoperative re-drift, recurrent esotropia (RET), and consecutive exotropia (CXT) in patients with infantile esotropia.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>CXT Group (n = 37)</th>
<th>RET Group (n = 43)</th>
<th>MFS Group (n = 32)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onset (months)</td>
<td>2.8 ± 1.8</td>
<td>2.6 ± 2.0</td>
<td>2.7 ± 2.2</td>
<td>.935&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Duration of esotropia (months)</td>
<td>17.1 ± 6.0</td>
<td>15.0 ± 8.0</td>
<td>17.5 ± 6.2</td>
<td>.254&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Age at surgery (months)</td>
<td>19.8 ± 6.4</td>
<td>17.7 ± 7.3</td>
<td>20.2 ± 6.9</td>
<td>.221&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Male sex</td>
<td>21 (56.8%)</td>
<td>25 (58.1%)</td>
<td>19 (59.4%)</td>
<td>.976&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Preoperative characteristics</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Angle of deviation (PD)</td>
<td>57.2 ± 10.6</td>
<td>54.7 ± 10.0</td>
<td>57.4 ± 11.1</td>
<td>.438&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Refractive error (D)</td>
<td>1.92 ± 0.83</td>
<td>1.88 ± 0.78</td>
<td>1.94 ± 0.74</td>
<td>.936&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fixation preference</td>
<td>28 (75.7%)</td>
<td>16 (37.2%)</td>
<td>10 (31.3%)</td>
<td>&lt; .001&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>DVD</td>
<td>11 (29.7%)</td>
<td>10 (23.3%)</td>
<td>6 (18.8%)</td>
<td>.595&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>IOOA</td>
<td>12 (32.4%)</td>
<td>10 (23.3%)</td>
<td>8 (25.0%)</td>
<td>.639&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Type of surgery</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMR</td>
<td>16 (43.2%)</td>
<td>22 (51.2%)</td>
<td>14 (43.8%)</td>
<td>.901&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Three-muscle surgery</td>
<td>17 (45.9%)</td>
<td>18 (41.9%)</td>
<td>14 (43.8%)</td>
<td></td>
</tr>
<tr>
<td>Four-muscle surgery</td>
<td>4 (10.8%)</td>
<td>3 (7.0%)</td>
<td>4 (12.5%)</td>
<td></td>
</tr>
<tr>
<td>Period of follow-up (years)</td>
<td>9.5 ± 3.8</td>
<td>9.1 ± 3.0</td>
<td>10.0 ± 4.7</td>
<td>.660&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

CXT = consecutive exotropia; RET = recurrent esotropia; MFS = monofixation syndrome; PD = prism diopters; D = diopters; DVD = dissociated vertical deviation; IOOA = inferior oblique overaction; BMR = bilateral medial rectus recession
<sup>a</sup>One-way analysis of variance.
<sup>b</sup>Chi-square test.
<sup>c</sup>Fisher’s exact test.
pic progression (OR: 15.07 per -1.00 D/year, 95% CI: 1.23 to 184.86) with the development of consecutive exotropia and increase in the angle of esodeviation at postoperative day 1 (OR: 1.15, 95% CI: 1.04 to 1.26) with recurrent esotropia development (Table 3).

The rate of postoperative development of DVD (21.6%, 16.3%, and 15.6% of the consecutive exotropia, recurrent esotropia, and monofixation syndrome groups, respectively), IOOA (16.2%, 18.6%, and 15.6% of the consecutive exotropia, recurrent esotropia, and monofixation syndrome groups, respectively), and adduction limitation (8.1%, 0.0%, and 3.1% of the consecutive exotropia, recurrent esotropia, and monofixation syndrome groups, respectively) were not significantly different among the groups (P > .05). The results of the Titmus test did not show differences between groups (P > .05) with favorable stereoacuity in 12.9% (4 of 31) of the consecutive exotropia group, 33.3% (12 of 36) of the recurrent esotropia group, and 48.1% (13 of 27) of the monofixation syndrome group, and with fair stereoacuity in 58.1% (18 of 31) of the consecutive exotropia group, 58.3% (21 of 36) of the recurrent esotropia group, and 48.1% (13 of 27) of the monofixation syndrome group.

DISCUSSION

This study investigated the development pattern of postoperative re-drift in patients with infantile esotropia and identified factors associated with the re-drift. There was a clear difference in the development pattern between exotropic and esotropic drift in that recurrent esotropia occurred predominantly within postoperative 1 year, whereas consecutive exotropia continued to appear even 10 years after surgery. The presence of fixation preference before surgery and the rate of myopic progression were related to the development of consecutive exotropia, whereas the angle of deviation at postoperative day 1 was associated with the occurrence of recurrent esotropia.

The mechanisms of esotropic re-drift after infantile esotropia surgery have not been established. A previous study reported that recurrence was related to a greater degree of preoperative esodeviation, which did not appear in our study. Freeley et al. reported that a high portion of patients with infantile esotropia who experienced recurrence after surgery had an accommodative element. However, none of the patients in this study demonstrated features related to accommodative components such as a decrease in the angle of deviation with the cor-

### TABLE 3

<table>
<thead>
<tr>
<th>Factor</th>
<th>Consecutive Exotropia</th>
<th>Recurrent Esotropia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Odds Ratio</td>
<td>95% CI</td>
</tr>
<tr>
<td>Age at surgery (months)</td>
<td>1.04</td>
<td>0.78 to 1.40</td>
</tr>
<tr>
<td>Duration of esotropia (months)</td>
<td>0.93</td>
<td>0.69 to 1.25</td>
</tr>
<tr>
<td>Male sex</td>
<td>1.25</td>
<td>0.38 to 4.09</td>
</tr>
<tr>
<td>Preoperative deviation (PD)</td>
<td>1.02</td>
<td>0.93 to 1.12</td>
</tr>
<tr>
<td>Preoperative refractive error (D)</td>
<td>0.78</td>
<td>0.37 to 1.66</td>
</tr>
<tr>
<td>Fixation preference</td>
<td>6.64</td>
<td>2.07 to 21.32</td>
</tr>
<tr>
<td>DVD</td>
<td>2.21</td>
<td>0.61 to 8.04</td>
</tr>
<tr>
<td>IOOA</td>
<td>0.74</td>
<td>0.20 to 2.71</td>
</tr>
</tbody>
</table>

CI = confidence interval; PD = prism diopters; D = diopters; DVD = dissociated vertical deviation; IOOA = inferior oblique overaction; BMR = bilateral medial rectus recession.
complete resolution of amblyopia does not ad-

In our study, the degree of deviation at postop-
erative day 1 was significantly associated with the
development of recurrent esotropia. Although pa-
tients in the recurrent esotropia group were more
esotropic than those of the other two groups on
postoperative day 1, they showed only an average of
2.2 PD of esodeviation. However, the angle contin-
ued to increase and approximately two-thirds of the
recurrent esotropia group eventually underwent re-
operation. This suggests that a small overcorrection
may produce better long-term results, even though
our study might not establish the reference value of
the degree of deviation at postoperative day 1 be-
cause of the relatively small number of cases.

Previous studies have suggested several fac-
tors associated with the development of consecu-
tive esotropia, including amblyopia,\textsuperscript{5,8} hyperopia
greater than +2.50 D,\textsuperscript{16} developmental delay,\textsuperscript{5,10} ab-
normal medial rectus attachment,\textsuperscript{17-19} stretched
scar,\textsuperscript{20,21} multiple strabismus surgeries,\textsuperscript{7} and ad-
duction limitation after esotropia surgery.\textsuperscript{7,8,22} In
this study, the presence of fixation preference be-
fore surgery was an important factor correlated
with the development of consecutive esotropia.
Because alternate fixation reflects equal vision, a
lack of this condition indicates amblyopia of the
non-preferred eye in patients with infantile esotro-
pia,\textsuperscript{11,23} which was reported to carry a higher risk
of the occurrence of consecutive esotropia.\textsuperscript{5,8}

The primary goal of occlusion treatment for
patients with infantile esotropia with fixation
preference is to produce an alternating pattern of
fixation before surgery. However, if this goal is
not achieved in a timely manner, clinicians
should decide whether to conduct surgery or con-
tinue occlusion treatment even with the delay
of operation. In this study, 74 patients demonstrat-
ed fixation preference at baseline examination and
they were prescribed occlusion treatment. Among
them, 20 patients achieved alternate fixation after
a mean 2.3 months of occlusion, but 54 patients
were unresponsive, even though they were treated
for a longer period (4.6 months on average; \( P < .001 \)) (data not shown). These patients refrac-
tory to occlusion treatment showed a high rate
of esotropic drift, which is contrary to previous
studies reporting that performing surgery before
complete resolution of amblyopia does not ad-
versely affect outcomes.\textsuperscript{24,25} Whether conducting
surgery before resolution of fixation preference
or continuing occlusion treatment with the delay
of surgery is more beneficial to such patients and
how long they need to perform occlusion therapy
should be clarified in further studies.

We identified the association between the annu-
ral rate of myopic progression and the development
of consecutive exotropia. Because the prevalence
of myopia has been increasing in Asian countries,
including Korea,\textsuperscript{26} this could be an ethnic-specific
association that was not found in Western studies.
Moreover, because consecutive exotropia developed
at postoperative 6.5 years on average, myopic shift
during postoperative 5 years may be a “risk factor”
for exotropic drift and contribute to the constant
nature of consecutive esotropia development over a
long period. However, it is difficult to explain the
mechanism of this phenomenon. Although previous
studies reported that childhood intermittent exotro-
opia influenced the development and progression of
myopia,\textsuperscript{27,28} the results of those studies cannot be
extrapolated to our study. Therefore, this finding
should be interpreted with caution.

The following must be considered to interpret
the results of our study. First, this study was con-
ducted retrospectively and limited by a relatively
small number of cases. Second, there was an inter-
val between the onset of infantile esotropia and the
time of operation. Although this could be explained
by the delay in coming to our hospital, which is a
tertiary medical institution, and in conducting oc-
closure treatment before surgery, it could be argued
that this delay may affect the results. However, the
results of this study were obtained by considering
such a delay because we put the duration of esotro-
pia on multinomial logistic regression as a variable.
Also, we did not find a significant correlation of du-
ration of esotropia itself with the re-drift.

Re-drift after surgery occurred in more than 70% of
patients with infantile esotropia during a long-
term observation period. There was a clear difference
in the development pattern between exotropic and
esotropic drift; most recurrent esotropia cases ap-
peared within postoperative 1 year, whereas consecu-
tive exotropia occurred constantly over a long period
of time. Detailed evaluation before surgery and close
observation of postoperative deviations and changes
in refractive status will help to determine the surgical
prognosis in patients with infantile esotropia.
REFERENCES


