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Assessment of the surgical outcomes of esotropia in pediatric subjects with high accommodative convergence/accommodation ratio: A clinical assessment

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Abstract---Background: Treating subjects with a high AC/A ratio and with esotropia is a challenging and complex procedure, often associated with increased near deviation which may lead to various outcomes following the surgery. Aims: The present study was conducted to assess outcomes following surgery in children with esotropia who were surgically treated with primary bilateral medial rectus (BMR) recessions. The study also compared preoperative and postoperative measurements in subjects with a high AC/A ratio to a normal AC/A ratio to assess surgical outcomes. Materials and Methods: 122 subjects were divided into 2 groups based on AC/A ratio into high AC/A ratio and normal AC/A ratio The subjects with high AC/A were treated with bifocal management if they had near persistent ET of $\geq 10\Delta$ in full cycloplegic correction and not if they had far ET of $\geq 10\Delta$. Target angle at the time of the surgery was assessed with stereopsis presence via positive butterfly/fly, and near and distance deviations $\leq 10\Delta$ within orthophoria. These success outcomes were compared in subjects with normal AC/A ratio and AC/A ratio groups. The collected data were subjected to statistical evaluation. Results: Postoperatively, the positive fly has seen in 6.93% (n=7) subjects with normal AC/A ratio group and in 14.28% (n=3) subjects from high AC/A ratio group. The negative fly was seen in 35.64%

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(n=36) subjects from the normal AC/A ratio group and in 38.09% (n=8) subjects from the high AC/A ratio group. Near deviation was also higher in the normal AC/A ratio group with $7.5\pm14.2\Delta$ compared to the high AC/A ratio group with $7.1\pm14.8\Delta$ deviation. This difference was also statistically non-significant with p=0.907. No significant difference in success rates was seen in subjects wearing spectacles compared to those not wearing them in both groups (p=0.17). Target angle statistically differs in normal AC/A ratio group and high AC/A ratio group with p=0.001. Target angle was associated with distance deviation preoperatively but not with near deviation.

Keywords---Esotropia, bilateral medial rectus recession, high AC/A ratio, target angle, strabismus surgery.

Introduction

Earlier, the treatment of partly accommodative esotropia surgically was to be conducted depending on the misalignment angle as assessed at 6 meters. Misalignment angle is obtained with the subject wearing their respective full cycloplegic refractive corrections. However, it has been for various years that in subjects with a high ratio of accommodative convergence to accommodation (AC/A) and when the near deviation is higher than 10 prism diopters (PD) to the distance deviation, in such cases, surgery, when performed using misalignment of 6 meters, often result in surgical under corrections in high numbers, which are unacceptable.¹

In subjects with a high AC/A ratio, Parks recommended the addition of 1mm to each medial rectus recession assessed. While Parks recommendations were being applied surgically of adding 1mm, surgical under corrections were very high in subjects, with the majority of subjects needing wearing bifocal continuously as to control their near deviation following the surgical procedure.² Subjects having esotropia are the common candidates presenting to take ophthalmic treatment. Treating strabismus of this kind is aimed at establishing normal ocular alignment to maximize binocular fusion and vision. Many subjects with esotropia are treated with surgical management, especially those who are not managed successfully with hyperopic correction, who are not fully accommodative, and those having infantile esotropia.

ET greater than the distance in subjects with high accommodative AC/A (accommodative convergence/accommodation) is also seen in the subset of the individuals not managed with hyperopic correction, who are not fully accommodative, and those having infantile esotropia.³ AC/A ratio is specific to the relationship between convergence amount that is generated based on accommodation amount. High AC/A ratio abnormally can be treated with full hyperopic correction. It sometimes with bifocal addition to decrease accommodation added for near fixation. Despite hyperopic correction with a bifocal, residual misalignment remains near and/or at distance. In such cases, surgery might be done to attain normal ocular alignment.⁴

Treating subjects with a high AC/A ratio and with esotropia is a challenging and complex procedure, often associated with increased near deviation which may lead to various outcomes following the surgery.⁵ The present study evaluated outcomes following surgery in children with esotropia who were surgically treated with primary bilateral medial rectus (BMR) recessions. The study also compared preoperative and postoperative measurements in subjects with high AC/A ratio to normal AC/A ratio to assess differences in postoperative stereopsis, alignment, and other surgical outcomes along with the selection of target angle.

Materials and Methods

The present retrospective clinical study was conducted to assess outcomes following surgery in children with esotropia who were surgically treated with primary bilateral medial rectus (BMR) recessions. The study also compared preoperative and postoperative measurements in subjects with a high AC/A ratio to a normal AC/A ratio to assess surgical outcomes. The study was conducted at SMBT Institute Medical Sciences and Research Center, Dhamangaon-Dhoti, Nashik, Maharashtra, after obtaining clearance from the concerned Ethical committee. The study population was comprised of the child subjects having esotropia, and who underwent bilateral medial rectus recession.

The bilateral medial rectus recession was carried out by ophthalmologists' expertise in the field. The exclusion criteria for the study were subjects where bilateral medial rectus recessions were to be treated with strabismus surgery, in subjects with less than 2 months follow-up, subjects without distance and near deviation measurements postoperatively, and preoperatively (3 months before surgery), and subjects with a history of strabismus surgery.

Collected data were demographics, medical history, ophthalmic history, use of refractive correction, cycloplegic refraction, target angle for surgery, angle of deviation at near and at distance, stereopsis, and visual acuity. Depending on the patient's cooperation level and age, visual activity was measured using either Snellen's chart, HOTV matching, or fixation pattern. As allowed by age, APCT (alternate prism cover testing) was used to measure deviations. In subjects under 1 year of age where age was not allowing APCT, Krimsky's technique was used to measure deviation. Initially, all measurements were taken by an Orthoptist expert in the field followed by reconfirmation by the surgeon operating. Stereo Butterfly test and Titmus Fly test were used to assess Stereopsis based on age. Using a combination of 1% tropicamide and 1% Cyclogyl were simultaneously instilled and repeated for cycloplegic refraction. The cycloplegic assessment was done 30 minutes after eyedrops placement and was considered appropriate with a minimum of 7mm pupillary dilation, and with no pupillary constriction on light reaction. Spectacle correction was given to all subjects before the surgery in cases with preoperative refractive error of +1.00 astigmatism, -0.50 diopters myopia, and >+1.50 1.50 diopters hyperopia.

The subjects were further divided based on AC/A ratio and high AC/A ratio where high AC/A ratio was concerned based on heterophoria method of AC/A assessment where ≥ 10 prism diopter (Δ) deviation increase was seen at near deviation in comparison to distance deviation. The subjects with high AC/A were

treated with bifocal management if they had near persistent ET of $\geq 10\Delta$ in full cycloplegic correction and not if they had far ET of $\geq 10\Delta$.

The target angle at the time of the surgery was assessed for the operating surgeon's discretion. Most of the operating surgeons considered the measurement of the near deviation. The success of the surgical procedure was assessed based on the parameters including stereopsis presence via positive butterfly/fly, and near and distance deviations $\leq 10\Delta$ within orthophoria. These success outcomes were compared in subjects with normal AC/A ratio and AC/A ratio groups. The collected data were subjected to the statistical evaluation using SPSS software version 21 (Chicago, IL, USA) and one-way ANOVA and t-test for results formulation. The data were expressed in percentage and number, and mean and standard deviation. The level of significance was kept at p<0.05.

Results

The present study was conducted to assess outcomes following surgery in children with esotropia who were surgically treated with primary bilateral medial rectus (BMR) recessions. The study also compared preoperative and postoperative measurements in subjects with a high AC/A ratio to a normal AC/A ratio to assess surgical outcomes. Initially, a total of 204 subjects were screened for the study, where only 158 subjects had undergone bilateral medial rectus recession for esotropia. 36 subjects were further excluded from the study as they had a follow-up of fewer than 2 months. Hence, 122 subjects finally made the sample size for the study.

In 122 subjects, 101 subjects had a normal AC/A ratio, whereas, 21 subjects had a high AC/A ratio assessed preoperatively. In all study subjects, 54 were capable of the stereopsis measurement postoperatively. The demographic characteristics of the study subjects are depicted in Table 1. It was seen that the mean age of the study subjects in normal AC/A ratio group subjects was 3.8 ± 4.12 years, and in subjects of group high AC/A ratio was 4.1 ± 3.68 years. This was statistically non-significant with p=0.758. The age range in the normal AC/A ratio group and high AC/A ratio group was 0.7-14 and 0.9-13.8 years respectively. There were 12 males and 9 females in the normal AC/A ratio group. This difference was also statistically non-significant with p=0.78. The mean follow-up duration for the study subjects and 27.7 ± 21.3 months.

Concerning preoperative parameters, it was seen that for stereopsis, the positive fly test was seen in 3.96% (n=4) subjects of normal AC/A ratio group and 4.76% (n=1) subject of high AC/A ratio group. A negative fly test was seen in 17.82% (n=18) subjects of the normal AC/A ratio group and 33.33% (n=7) subjects from the high AC/A ratio group. The difference in stereopsis between the two groups was statistically non-significant with p=0.86. For deviation, distance deviation was higher in the normal AC/A ratio group with $38.5\pm13.7\Delta$ compared to the high AC/A ratio group with 31.9 ± 15.1 . This difference was statistically non-significant between the two groups with p=0.06. Near deviation was significantly higher in the high AC/A ratio group with $45.9\pm14.2\Delta$ compared to $38.3\pm13.5\Delta$ in the normal AC/A ratio group. This difference was statistically significant with p=0.02 (Table 2). 12 subjects from the high AC/A ratio group and 40 subjects from the normal

AC/A ratio group were given spectacles postoperatively. Infantile esotropia was not assessed as there were only 4 study subjects with infantile esotropia.

On assessing the postoperative parameters, the study results showed that in stereopsis, the positive fly was seen in 6.93% (n=7) subjects with normal AC/A ratio group and in 14.28% (n=3) subjects from high AC/A ratio group. The negative fly was seen in 35.64% (n=36) subjects from the normal AC/A ratio group and in 38.09% (n=8) subjects from the high AC/A ratio group. This difference was statistically non-significant with p=0.42. For deviations, distance deviation was higher in the normal AC/A ratio group with 5.4±13.9 Δ compared to the high AC/A ratio group with p=0.245. Near deviation was also higher in the normal AC/A ratio group with 7.5±14.2 Δ compared to the high AC/A ratio group with 7.1±14.8 Δ deviation. This difference was also statistically non-significant with p=0.907 (Table 3).

No significant difference in success rates was seen in subjects wearing spectacles compared to those not wearing them in both groups (p=0.17). Target angle statistically differs in normal AC/A ratio group and high AC/A ratio group with p=0.001. Target angle was associated with distance deviation preoperatively but not with near deviation.

Discussion

The present study was conducted to assess outcomes following surgery in children with esotropia who were surgically treated with primary bilateral medial rectus (BMR) recessions. The study also compared preoperative and postoperative measurements in subjects with a high AC/A ratio to a normal AC/A ratio to assess surgical outcomes. Among 122 subjects, 101 subjects had a normal AC/A ratio, whereas, 21 subjects had a high AC/A ratio assessed preoperatively. The mean follow-up duration for the study was 27.7±21.3 months.

In preoperative parameters, it was seen that for stereopsis, the positive fly test was seen in 3.96% (n=4) subjects of normal AC/A ratio group and 4.76% (n=1) subject of high AC/A ratio group. A negative fly test was seen in 17.82% (n=18) subjects of the normal AC/A ratio group and 33.33% (n=7) subjects from the high AC/A ratio group. The difference in stereopsis between the two groups was statistically non-significant with p=0.86. For deviation, distance deviation was higher in the normal AC/A ratio group with $38.5\pm13.7\Delta$ compared to the high AC/A ratio group with 31.9±15.1. This difference was statistically non-significant between the two groups with p=0.06. Near deviation was significantly higher in the high AC/A ratio group with $45.9\pm14.2\Delta$ compared to $38.3\pm13.5\Delta$ in the normal AC/A ratio group. This difference was statistically significant with p=0.02. 12 subjects from the high AC/A ratio group and 40 subjects from the normal AC/A ratio group were given spectacles postoperatively. Infantile esotropia was not assessed as there were only 4 study subjects with infantile esotropia. These findings were consistent with the results of Kushner BJ⁶ in 2001 and Cerman E et al⁷ in 2014 where comparable preoperative findings were suggested by the authors.

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The study results showed that postoperatively, in stereopsis, the positive fly was seen in 6.93% (n=7) subjects with normal AC/A ratio group and in 14.28% (n=3) subjects from high AC/A ratio group. The negative fly was seen in 35.64% (n=36) subjects from the normal AC/A ratio group and in 38.09% (n=8) subjects from the high AC/A ratio group. This difference was statistically non-significant with p=0.42. For deviations, distance deviation was higher in the normal AC/A ratio group with $5.4\pm13.9\Delta$ compared to the high AC/A ratio group with $1.6\pm11.9\Delta$. This difference was statistically non-significant with p=0.245. Near deviation was also higher in the normal AC/A ratio group with $7.1\pm14.8\Delta$ deviation. This difference was also statistically non-significant with p=0.907. These results were in agreement with the results of the studies by Lueder BT et al⁸ in 2006 and Li B et al⁹ in 2019 where postoperatively similar findings were seen in subjects concerning deviation and stereopsis in their study.

No significant difference in success rates was seen in subjects wearing spectacles compared to those not wearing them in both groups (p=0.17). Target angle statistically differs in normal AC/A ratio group and high AC/A ratio group with p=0.001. Target angle was associated with distance deviation preoperatively but not with near deviation. This was similar to what is reported by Park KA¹⁰ in 2017 and Tejedor J et al¹¹ in 2018 where comparable success postoperatively following bilateral medial rectus (BMR) recessions for esotropia was reported by the authors.

Conclusion

Within its limitations, the present study concludes that subjects having a high AC/A ratio are suitable candidates for bilateral medial rectus (BMR) recessions for esotropia treatment, and are comparable to subjects with a normal AC/A ratio. Target angle was found to be associated with distance deviation preoperatively but not with near deviation. However, the present study had a few limitations including small sample size, short study duration, retrospective nature, and geographical area biases. Hence, more longitudinal studies with a larger sample size and longer monitoring period will help reach a definitive conclusion.

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TABLES

Table 1 Demographic characteristics of the study subjects

| Characteristics | Normal AC/A ratio | High AC/A ratio | p-value |
|----------------------------------|-------------------|-----------------|---------|
| Age Range (years) | 0.7-14 | 0.9-13.8 | - |
| Mean age (years) | 3.8±4.12 | 4.1±3.68 | 0.758 |
| Gender | | | |
| Males | 12 | 57 | 0.78 |
| Females | 9 | 44 | |
| Mean Follow-up duration (months) | 27.7±21.3 | | - |

Table 2 Comparison of stereopsis and deviation preoperatively in two study groups (Δ): Prism dioptres

| Preoperative parameters | Normal AC/A ratio $(n-101) = (0)$ | High AC/A ratio | p-value |
|-------------------------|-----------------------------------|-------------------|---------|
| | (n=101) n (%) | (n=21) n (%) | |
| Stereopsis | | | |
| Positive Fly | 4 (3.96) | 1 (4.76) | 0.86 |
| Negative Fly | 18 (17.82) | 7 (33.33) | |
| Deviations (Δ) | | | |
| Distance | 38.5±13.7 | 31.9±15.1 | 0.06 |
| Near | 38.3±13.5 | 45.9±14.2 | 0.021 |

Table 3Comparison of stereopsis and deviation postoperatively in two study groups (Δ):Prism dioptres

| Postoperative parameters | Normal AC/A ratio | High AC/A ratio | p-value |
|--------------------------|-------------------|-----------------|---------|
| Stereopsis | | | |
| Positive Fly | 7 (6.93) | 3 (14.28) | 0.42 |
| Negative Fly | 36 (35.64) | 8 (38.09) | |
| Deviations (Δ) | | | |
| Distance | 5.4±13.9 ∆ | 1.6±11.9 Δ | 0.245 |
| Near | 7.5±14.2∆ | 7.1±14.8∆ | 0.907 |