A retrospective review of ocular alignment after large angle congenital esotropia surgery

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Declaration

I, Roland Höllhumer declare that this research report is my own work. It is being submitted for the degree of Master of Medicine in Ophthalmology to the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other university.

26th Day of August 2014

The patients reviewed for this research report were all collected and managed at St John Eye Hospital, the Ophthalmology unit of Chris Hani Baragwanath Hospital in Soweto, Johannesburg, South Africa

Ethics Approval

This study was approved by the Human Ethics Research Committee (Medical) of the University of the Witwatersrand: Certificate clearance number: M130943

Presentations Arising from this Study

The results of this study will be presented at the Ophthalmological Society of South Africa's annual congress in March 2015

Title: A retrospective review of ocular alignment after large angle congenital esotropia surgery

Presenter: Roland Höllhumer

Abstract

Purpose: The main aim of this study is to evaluate the success of bimedial rectus recessions as a primary surgical procedure for patients presenting with congenital esotropia. Secondly the demographic (age, gender and race) data of the study group is described. Lastly the success of surgery is compared to the age of the patients at the time of surgery.

Methods: A retrospective review of 52 patients with congenital esotropia of ≥50$^{\Delta}$ was done. All patients underwent bimedial rectus recessions and were followed up post-operatively for a minimum of 6 months.

Results: The study period extended from January 1992 - September 2003. 52 Patients were included in the study group. The pre-operative angle of deviation ranged from 50-85$^{\Delta}$. The ages of the patients ranged from 15 months to 22 years, with a mean of 5.3 years and a median of 4 years. The gender distribution was 42% male (n=20) and 58% female (n=28). Surgery was successful (within 10$^{\Delta}$ of orthophoria) in 77% (n=40), a partial success (10-20$^{\Delta}$ from orthophoria) in 17% (n=9) and a failure (more than 20$^{\Delta}$ from orthophoria) in 6% (n=3). No statistically significant relationship was found between the success of surgery and the age of the patients at the time of surgery.

Conclusion: This study confirms that a bilateral medial rectus recession, performed as a primary procedure for patients with a large angle (>50$^{\Delta}$) congenital esotropia, has a high success rate. This corresponds to the the outcomes of similar international studies.

Acknowledgements

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Introduction

Esotropias are the most common form of strabismus, making up more than 50% of paediatric ocular deviations.[1,2] Congenital esotropias are the commonest type of esotropia. Congenital esotropia consists of an inward deviation of the eyes, and has its onset before 6 months of age. The prevalence in the general population of congenital esotropia is approximately 1%.[1] In patients with neurological and developmental abnormalities, the prevalence of esotropia may be as high as 30%.[2]

In patients with congenital esotropia, the deviation is usually more than 35$^{\Delta}$ (prism diopters) in size, commitant and unchanged between near and far gaze. 75% of patients have an inferior oblique overaction, usually developing by 2 years of age. This produces a V-pattern on examination. Likewise 75% of patients may have dissociated vertical deviation.[2]

Assessment

Before a management plan for a child with esotropia can be instituted, the child needs to undergo a thorough ophthalmic assessment. This involves a complete ocular examination that includes assessing visual acuity, evaluation of ocular alignment and ocular movements. The evaluation of vision in infants can be challenging. It can be assessed with the use of fixation targets or an optokinetic drum. Fixation targets need to be well delineated structures. This can be in the form of picture charts such as the Kay cards or Cardiff cards. It is important to note that horizontal smooth pursuit is normally asymmetric up until 6 months of age, with the temporal to nasal smooth pursuit being more developed.

All patients require a cycloplegic refraction to exclude any significant refractive errors. A hyperopic refractive error of 1-2 diopters is normal in young children and is commonly found. Patients with accommodative esotropia have an average of 4 diopters of hyperopia.[1]

The evaluation of ocular alignment starts off with an observation of the position of a patient's head. Head tilts and turns give a clue to paralytic or restrictive strabismus, with the head in a position that maximizes binocular single vision. Ocular alignment can be assessed by looking at the corneal light reflexes and performing cover tests. There are two tests that make use of the corneal light reflex: the Hirschberg and the Krimsky tests.[2] The cover tests are used to detect horizontal and vertical strabismus.[2] These include the cover/uncover test, the alternate cover test and the simultaneous prism and cover test.[1,2]

Ocular movements are evaluated as versions and ductions. Versions are movements of both eyes together. The term duction refers to the movements of each eye assessed individually.[2] Patients with esotropia may appear to have an abduction deficit due to cross fixation. This is a phenomenon where the child views the temporal visual field on the one side with the contralateral eye, thereby negating the abduction of the ipsilateral eye and creating an impression of an abduction deficit.[1]

Management

The management of congenital esotropia is mainly surgical. Surgery is only done once reproducible measurements of the ocular deviation have been obtained and any element of amblyopia has been treated. Amblyopia can be treated by patching or by pharmacologically penalising the normal eye with atropine eye drops.

The timing of the surgery is an area of great debate, with two main schools of thought. The first school advocates early surgery within the first year or even at 6 months of age. The proponents of this school believe that there is an improved stereopsis outcome in these patients. The second school of thought advocates a delay in surgery until 2 years of age, when any inferior oblique overaction and dissociated vertical deviation should be apparent. Delaying esotropia surgery allows for these associated deviations to become manifest and to be corrected in one operation.[2] Small angle esotropias may resolve spontaneously in the first six months of life. The Congenital Esotropia Observational Study showed that stable angles of more than 40$^{\Delta}$ are unlikely to resolve spontaneously and these patients are therefore candidates for early surgery.[3]

There are two main surgical approaches. The first involves operations on both eyes, with bilateral medial rectus recessions and possible lateral rectus resections. The second involves surgery on only one eye with a medial rectus recession and a lateral rectus resection.[2] At St John Eye Hospital (St John) patients with untreatable or significant residual amblyopia in one eye usually follow the second surgical approach (surgery involving only the amblyopic eye) while other patients follow the first. A medial rectus recession is a weakening procedure of the medial rectus muscle, that will cause the eye to deviate outwards. A lateral rectus resection is a strengthening procedure of the lateral

rectus muscle that augments the outward deviation of the eye. One or both of these procedures can therefore be employed in one or both eyes in esotropia, to deviate the eye outwards and achieve alignment of the two eyes. The benefit of bimedial rectus recessions is that it is a faster procedure and leaves the lateral rectus untouched if there is the need for subsequent surgery.[4]

The amount of recession or resection of the muscles is based on the Calhoun algorithm: each millimeter that the medial rectus is recessed is equivalent to 4^{Δ} of alignment change, each millimeter of resection of the lateral rectus is equivalent to 2^{Δ} change in alignment.[5] It was previously thought that inserting muscles behind the equator would cause a limitation of ocular movement. However, it has been shown in various studies that this is not the case. This has allowed for an increased amount that a muscle is recessed.[6] At St John the maximal medial rectus recession performed is 7.5mm and the maximal lateral rectus resection performed is 10mm.[5] It has been suggested that an alignment within 10^{Δ} of orthophoria at the 6 month follow-up can be considered a surgical success.[4,6]

Literature

Forrest et al[4] did a retrospective study of 49 patients with large angle esotropia (>55^{Δ}) who underwent three muscle surgery, consisting of a bimedial rectus recession and lateral rectus resection. They had a success rate of 91% at the 6 month follow up.

Thomas et al[6] did a retrospective study on the success of a single surgical procedure, including 2/3/4 muscle surgery, for large angle (>50^{Δ}) strabismus. The esotropia arm had an overall success rate of 69% with a mean follow up time of 4.7 months.

Damanakis et al[7] reviewed the success of bilateral 8mm medial rectus recessions in 16 patients. They found that 75% of the cases were successful, while 25% were under corrected and required further lateral rectus surgery. None of the patients was overcorrected or had adduction deficits post-operatively.

Vroman et al[8] did a retrospective analysis of patients with congenital esotropia. They compared the success of two muscle surgery in patients with esotropia of less than 50$^{\Delta}$ with two muscle surgery for esotropia of more than 50$^{\Delta}$. The recession for the smaller angles was based on a surgical dosage table. The bimedial rectus recessions dosage used for large angles was 6.5mm for 55-60$^{\Delta}$ and 7mm for greater than 65$^{\Delta}$. The mean follow up time was 32 months for the large angle group. 16 patients were assigned to the large angle group (>50$^{\Delta}$ esotropia) and had a 75% success rate. None of the patients developed a consecutive exotropia.

Rowe et al[9] looked at children with esotropia who underwent surgical correction before two years of age and were followed up until at least four years of age. The patients underwent either bimedial rectus recessions or a unilateral medial rectus recession with a lateral rectus resection. When looking at the results, 24 out of the 40 study patients had an esotropia of greater than 50$^{\Delta}$. Eight of the 24 underwent a recess-resect procedure with a 38% success rate. The rest of the patients underwent a bimedial rectus recession with a 31% success rate.

Szmyd et al[10] did a retrospective review of 45 patients with a congenital esotropia of more than 50$^{\Delta}$ who underwent bimedial rectus recessions of 6-7mm. Thirty seven of the patients had deviations from 50-65$^{\Delta}$ and underwent 6mm recessions. Eight of the patients had deviations in excess of 70$^{\Delta}$ and underwent 7mm recessions. There was an 89% success rate in the first group and a 100% success rate in the latter group. The overall success for bimedial rectus recessions in this large angle esotropia study was 91%.

Nelson et al[11] reviewed the records of 97 patients with congenital esotropia of more than 50$^{\Delta}$ that were followed up for more than 6 months post-operatively. Eighty eight of the patients had deviations of 50-70$^{\Delta}$ and underwent 6mm bimedial rectus recessions. The remaining patients had deviations greater than 70$^{\Delta}$ and had 7mm bimedial rectus recessions. The first group had a success of 83% and the second group of 89% at 6 months post-operatively. The overall success was 83.5%.

Weakley et al[12] reviewed the surgical records of 36 patients with an infantile esotropia of greater than 60$^{\Delta}$ who underwent bilateral 7mm medial rectus recessions. They had an 85% success rate at 6 months post-operatively. This dropped to 75% success with a longer follow up (mean 18.2 months). This was mostly attributed to the late onset of an accommodative element that worsened a previously corrected esotropia. They additionally found that ocular alignment 6 weeks after the operation had a high predictive value for final outcome.

Scott et al [13] did a retrospective review of patients who underwent two muscle surgery or more than 2 muscle surgery for congenital esotropia of more than 50$^{\Delta}$. They had 59 patients who underwent two muscle surgery, being either a bimedial rectus recession (n=57) or unilateral medial rectus recession with lateral rectus resection (n=2). The bimedial recessions ranged from 5-6.5mm, less than the current maximum of 7.5mm. They had a surgical success in only 37% of the patients, whilst 58% were under corrected.

Lee et al[14] did a retrospective review of congenital esotropia patients with an angle of greater than 50$^{\Delta}$. They did bimedial rectus recessions of 4.5-5mm together with bilateral lateral rectus resections of 4-8mm. They had a 61% success rate with this, with the rest requiring a second and even third procedure. The patients that required further surgery were an average of 11 months younger than the successful group.

Hess et al[15] did a review of patients with congenital esotropia of more than 35$^{\Delta}$ who underwent a graded bimedial rectus recession. There were 11 patients with an angle of deviation greater than 60$^{\Delta}$ who underwent recessions of 7-8mm. There was a 55% success rate.

There is a paucity of local studies evaluating the outcome of strabismus surgery performed in South Africa. State hospitals are burdened by a large workload and so the reduction of secondary strabismus surgeries in patients with large angle congenital esotropia, would go a long way to maximize efficient utilization of theatre time. It will be useful to review the available records of large angle esotropia surgery at our own institution to assess the success of surgical alignment.

Materials and Methods

Design

This is a retrospective study of 52 patients with large angle congenital esotropia that were operated at St John Eye Hospital. For the purpose of this study a large angle esotropia is defined as an angle greater than 50$^{\Delta}$ in primary gaze. The sample size was chosen based on the literature review, in which the studies[6,7,8] used a sample size of 50 patients and were able to achieve statistically significant results.

Sample Assessment and Intervention

All patients were fully evaluated by ophthalmology registrars to exclude any underlying systemic, neurological or ocular diseases. The patients were then referred to the resident optometrist for a cycloplegic refraction to exclude any significant refractive error. A refractive error of greater than 3 diopters from emmetropia was considered to be significant.[1] If the above examinations revealed no abnormalities other than the underlying squint, the patients were referred to the resident orthoptist for a comprehensive examination of the ocular motility and alignment. The orthoptist made use of the cover/ uncover test, alternate cover test, Krimsky test and/or the Hirschberg test to evaluate the angle of ocular deviation. This angle of deviation was then entered into the orthoptist's register as the pre-operative angle of esotropia. If more than one assessment was done, the final accepted pre-operative assessment was entered into the register. If amblyopia was found, this was managed with patching or penalising with atropine. If amblyopia was absent and the measurement of the deviation was constant, the patients were referred for

surgery. The patients were operated by consultants and registrars at St John. The following alignment algorithm was used: each millimeter that the medial rectus is recessed is equivalent to 4$^{\Delta}$ of alignment change, each millimeter of resection of the lateral rectus is equivalent to 2$^{\Delta}$ change in alignment.[5]

Follow up

The patients were reviewed post-operatively at day 1 by the surgeon responsible for the surgery. If the surgery was uneventful the patient was discharged and reviewed within a month at the paediatric ophthalmology clinic. At this visit the patient was seen by both the orthoptist and doctors in the paediatric ophthalmology clinic. At this point the orthoptist's register was updated regarding the post-operative ocular alignment and any abnormalities in ocular motility were noted. Following this visit the patients were seen at various intervals, (usually after 6 weeks, 3 months and 6 months), with the register being updated at each visit.

Data Capture

The records of the orthoptist were used to complete the data capture sheets (Appendix A). The data were collected from the register between January 1992 and September 2003. The patients were chosen solely on the diagnosis of a congenital esotropia measuring more than or equal to 50$^{\Delta}$ in size. Surgery was regarded as successful if the post-operative deviation was within 10$^{\Delta}$ of orthophoria (esotropia or exotropia), a partial success if the post-operative deviation was between 10-20$^{\Delta}$ and a failure if the post-operative deviation was more than 20$^{\Delta}$ from orthophoria at 6 months or longer after surgery.[4]

The **inclusion criteria** were:

- Onset of esotropia before 6 months of age
- Only patients where a bimedial rectus recession was performed
- At least 6 months post-operative follow up

The **exclusion criteria** were:

- Neurological abnormalities
- Amblyopia
- Developmental delays
- Nystagmus
- Refractive errors of more than 3 diopters from emmetropia
- History of botulinum toxin injections or previous squint surgery

At times it may be difficult to assess amblyopia in young children, and this was a relative exclusion criteria.

Data Collection and Statistical Analysis

The captured data was analysed with the following outcome measures in mind:

- Objective 1: Description of the patient demographics, including age, gender and race
- Objective 2: Determination of the rate of successful, partial success and failure of surgery
- Objective 3: Comparison of the success of surgery with age of the patient at the time of surgery
- Objective 4: To review the rate of re-operation that would be needed in the groups with partial success and failure of surgery.

Complications that occurred during and after the surgery were not recorded in the orthoptists' register, and so this was not included as an objective in this study.

The hypothesis of this study is that the surgery results at St John compare favourably with published results.

The data were entered from the orthoptist's register into the data capture form (Appendix A). Patients with incomplete data sheets were excluded from the study.

The demographics in objective one were described as follows. Age is a continuous variable and the range, mean and median were described for the total group of patients and for the three sub-groups (successful, partial success and failure). Gender is a categorical variable and the frequency was described for the total group and the three sub-groups of patients. Race is also a categorical variable and its frequency was described for the total group as well as the three sub-groups.

For objective two the variables are categorical and the frequencies were calculated for each of the three subgroups (successful, partial success and failure).

Objective three compares the success of surgery with the age of the patient at the time of surgery. This compares a categorical variable with a continuous variable. Due to the lack of normality in the age distribution the Kruskal-Wallis formula was used to compare the statistical significance of these two variables. The test was done at an alpha of 5% ($p \leq 0.05$).

Objective four evaluates the rate of re-operation needed, a categorical variable. The frequency was calculated.

The 'Stata version 13.1' computer software was used for the statistical analysis.

Results

The study period commenced in January 1992 and ended in September 2003. Fifty-two patients of a potential 475 patients met the inclusion criteria for this study. The main reason for patients to be excluded, was that at least six months of post-operative follow-up was not documented. The pre-operative angle of deviation ranged from 50-85$^{\Delta}$ of esotropia. Figure 1 demonstrates the distribution of pre-operative deviation. The angle of deviation in most patients ranged from 50-65$^{\Delta}$ (n=44), with only 7 patients having a deviation more than 70$^{\Delta}$ and only one patient above 80$^{\Delta}$.

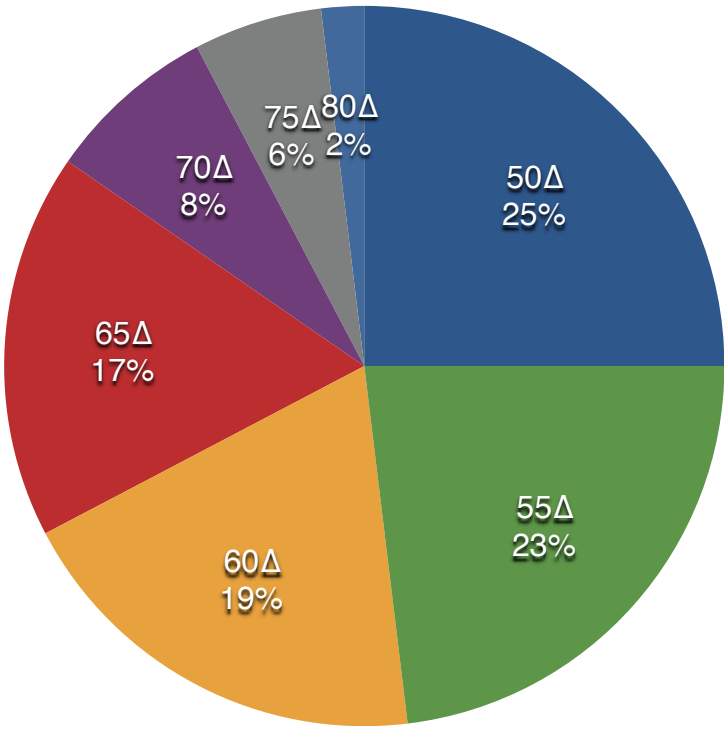

Figure 1: Pre-operative Distribution of Angle of Esotropia

Table 1: Pre-operative Distribution of Angle of Esotropia

Angle of Esotropia	Number of Patients	Percentage
50	n=13	25%
55	n=12	23%
60	n=10	19%
65	n=9	17%
70	n=4	8%
75	n=3	6%
80	n=1	2%

The patients ranged in age from 15 months to 22 years, with a mean of 5.3 years and median of 4 years. Figure 2 demonstrates the age distribution. As can be seen, it is skewed with most patients being under 10 years old.

Figure 2: Age Distribution

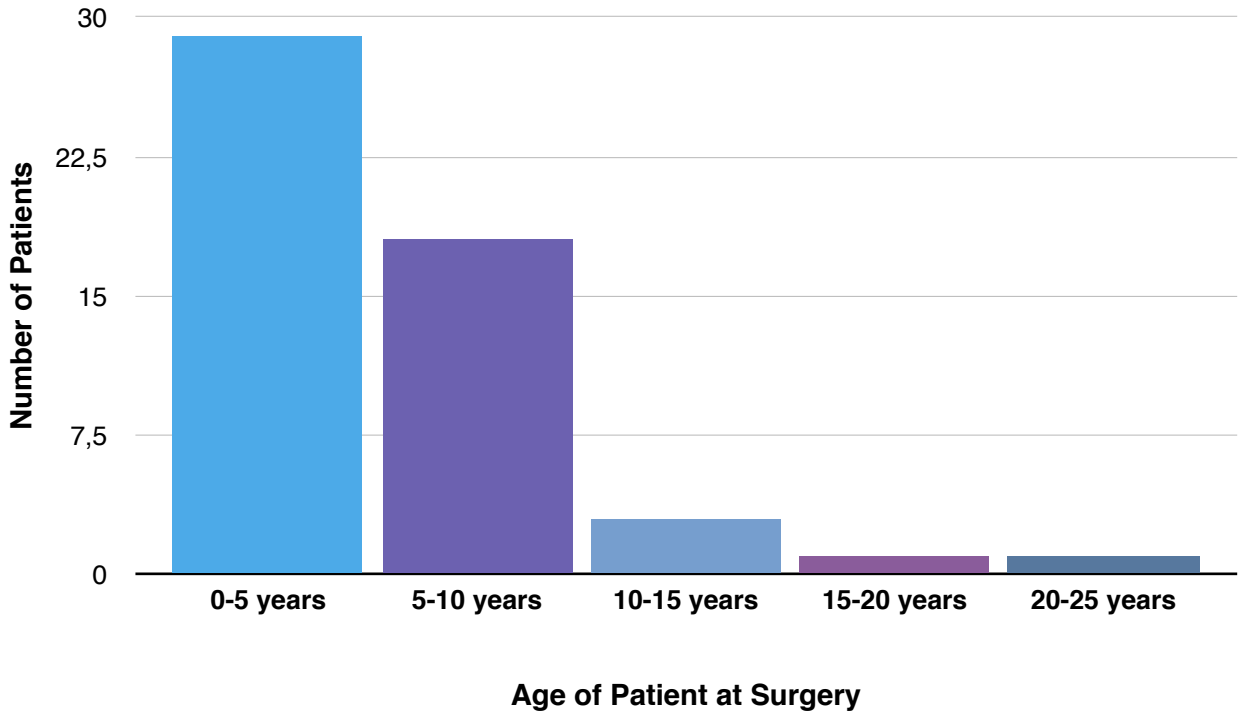

Table 2: Age Distribution

Age of Patient at Surgery	Number of Patients	Percentage
16 Months	n=1	2%
18 Months	n=2	4%
2 Years	n=5	9%
3 Years	n=13	25%
4 Years	n=8	15%
5 Years	n=7	13%
6 Years	n=4	8%
7 Years	n=2	4%
8 Years	n=3	6%
9 Years	n=2	4%
11 Years	n=2	6%
12 years	n=1	2%
18 Years	n=1	2%
22 Years	n=1	2%

In the study group there is a slight female preponderance of 58% (n=28), while 42% (n=20) of the patients were males. All patients in this study were African (n=48). The gender and race classification of four patients was not documented in the register.

Figure 3: Gender Distribution

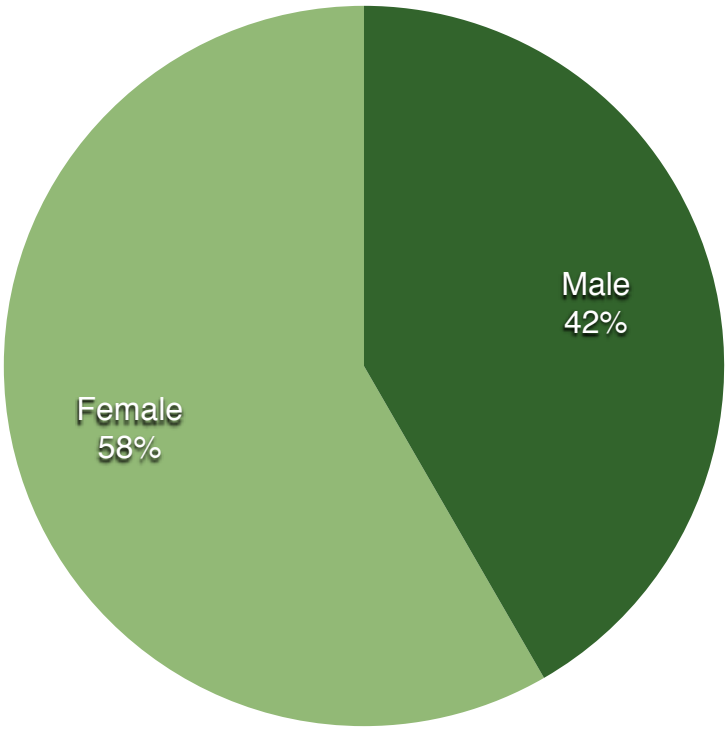

Table 3: Gender Distribution

Gender	Number of Patients	Percentage
Male	n=20	42%
Female	n=28	58%

Successful Group

The rate of surgical success was 77% (n=40). The ages in this group ranged from 15 months to 18 years, with a mean of 5 years and a median of 4 years. The gender distribution was 44% (n=16) male and 56% (n=20) female. There were four patients in this group whose demographic data was not available. Four of the patients had a consecutive exotropia up to 8$^{\Delta}$, 33 of the patients had a residual esotropia up to 10$^{\Delta}$ and 3 patients were completely orthophoric at the 6 month follow-up.

Partial Success Group

The partial success rate was 17% (n=9). 67% (n=6) were under corrected, whilst 33% (n=3) had a consecutive exotropia ranging from 12-16$^{\Delta}$. The ages in this group ranged from 2 years to 6 years, with a mean of 4.1 years and a median of 4 years. The gender distribution was 22% (n=2) male and 78% (n=7) female.

Failure Group

The failure rate was 6% (n=3). These were all unsuccessful due to under correction, with a residual esotropia ranging from 30-75$^{\Delta}$. The ages in this group ranged from 8 years to 22 years, with a mean of 12.7 years and a median of 8 years. The gender distribution was 67% (n=2) male and 33% (n=1) female.

Figure 4: Results Distribution

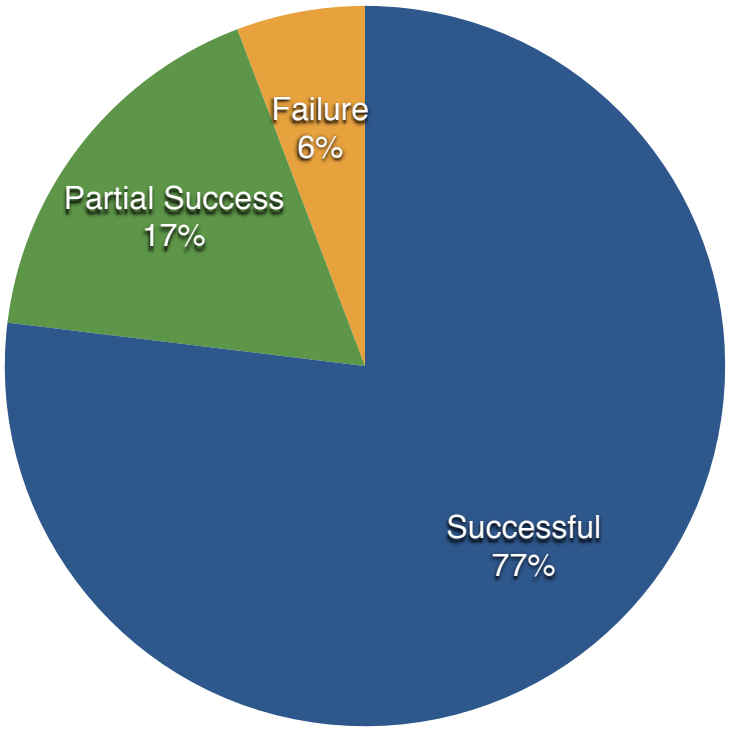

Table 4: Results Distribution

Surgical Outcome	Number of Patients	Percentage
Successful	n=40	77%
Partial Success	n=9	17%
Failure	n=3	6%

Age at the time of operation was evaluated for normality using the Shapiro-Wilk test. It was found that the data did not have a normal distribution. For this this reason the Kruskall-Wallis test was used to compare the age of patients at surgery with the surgical outcome. This test showed an almost statistically significant relationship between age and surgical success, with a p= 0.06. However, it does not meet the criteria for statistical significance where a p-value is ≤0.05.

The follow-up period ranged from 6 months to 6 years and 4 months, with a mean of 21 months. Figure 5 demonstrates the distribution of the follow-up period. Most patients were followed for 20 months or less.

Figure 5: Follow-up Period

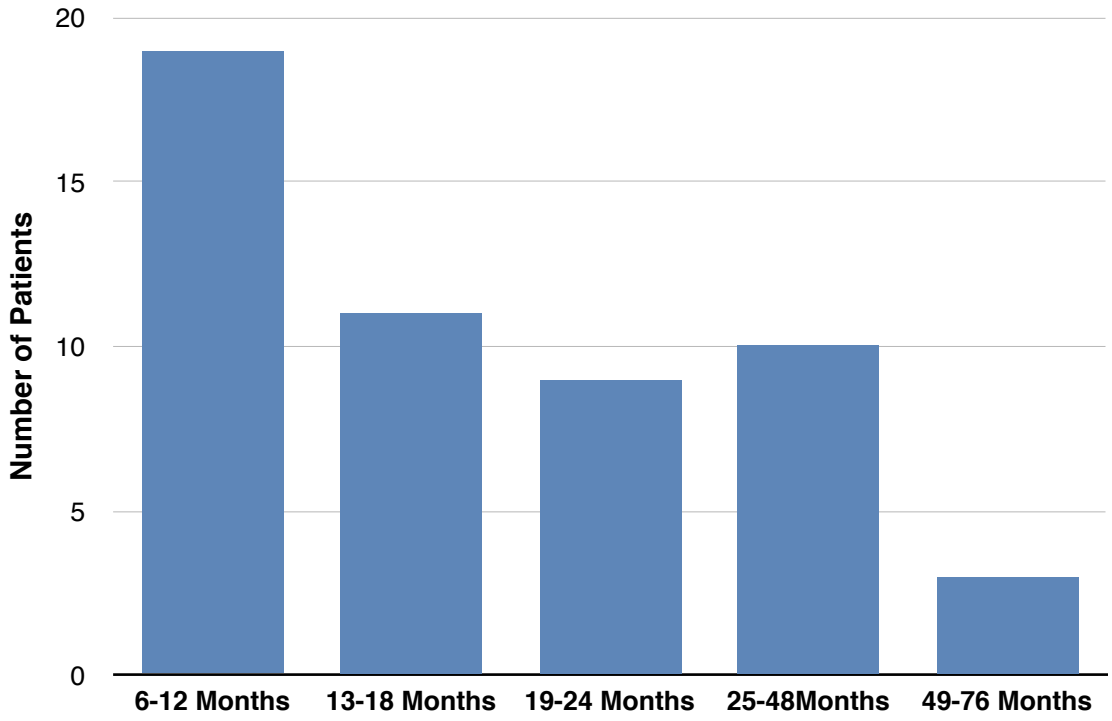

Table 5: Follow-up Period

	Number of Patients	Percentage
6-12 Months	n=19	37%
13-18 Months	n=11	21%
19-24 Months	n=9	17%
25-48 Months	n=10	19%
49-76 Months	n=3	6%

There were no patients that were recorded as having second procedures.

Discussion

This study demonstrates a good surgical outcome for patients with a large angle esotropia undergoing bimedial rectus recessions as a primary procedure. The success rate of 77% compares favourably with other studies in the literature.

Damanakis et al[7] reviewed 16 patients with a congenital esotropia of 80-90$^{\Delta}$ who underwent 8mm bimedial rectus recessions. They showed a success rate of 75%. The maximal recessions done in the current study was 7.5mm, showing similar results. Damanakis's study may indicate that for extremely large deviations (80-90$^{\Delta}$), larger recessions than what is performed at St John may be needed to achieve similar results. However this current study had only one patient with an angle of deviation of more than 80$^{\Delta}$ who did have a successful outcome.

Vroman et al[8] reviewed patients with congenital esotropia undergoing surgery. The patients with deviations of more the 50$^{\Delta}$ underwent a 6.5-7mm bimedial rectus recession with a success rate of 75%. This current study generally used a slightly larger maximal recession of 7.5mm, but showed similar results.

Weakley et al[12] reviewed the surgical results of patients with deviations greater than 60$^{\Delta}$ undergoing 7mm bimedial rectus recessions. Their early results showed a 85% success rate (at 6 months), however this decreased to 75% with longer follow up (18 months). The late failures were attributed to an accommodative element. The current study followed up patients for at least 6 months. The number of patients requiring spectacles at a later date was only five. All the children who needed spectacles were 3 years or older and none were surgical failures with their spectacle correction. This number may however be skewed due to follow-up failure after 6 months in many patients. It is therefore important to bear the accommodative element in mind in patients with late onset failures after initially successful surgery. They additionally found that the 6 week post-operative follow-up was a good predictor of final outcome. In the current study, although all patients were followed up for at least 6 months, the follow-up was sometimes haphazard and only 15 of the 52 patients had a follow-up at the 6 week post-operative interval. Of these patients, 11 were a surgical success at 6 weeks and 10 remained a surgical success at the last follow up, while one patient became a partial success. Three of the patients were a partial success at 6 weeks, with one becoming successful and the other 2 becoming failures at the last visit. There was one failure at the 6 week follow up that remained so at the final follow up. This seems to support Weakely et al[12] in that almost all the successes at 6 weeks were successful at the last follow up. The partial successes and failures tended to remain so or worsen with time. This was however a small sample in our study.

Scott et al[13] did a review of patients undergoing 2 muscle surgery for large (greater than 50$^{\Delta}$) angle congenital esotropia. 57 of these patients had bimedial rectus recessions of only 5-6.5mm, less than the standard amount. They suffered a success rate of only 37%. Thus supporting our practice of larger recessions in patients with larger angles of deviation. As is used at St John, each millimeter of medial rectus recession equates to a 4$^{\Delta}$ decrease in esotropia. So that a deviation of 50$^{\Delta}$ will have recessions of 6mm as a minimum primary procedure, rather than the 5mm used by Scott et al.

This study therefore correlates well with the current literature in supporting large bimedial rectus recessions for large angle congenital esotropia. This study had a success rate of 77%, partial success rate of 17% and failure rate of only 6%. There were seven patients (13%) of the total of fifty-two who were overcorrected and had consecutive exotropia. Of these, four had an overcorrected angle within 10$^{\Delta}$ of orthophoria and were considered a surgical success and not a significant overcorrection. The three other overcorrected patients formed part of the partial success group as their consecutive exotropia measured between 10-20$^{\Delta}$. The first patient had a deviation of 50$^{\Delta}$ but had a bimedial rectus recession of 6.5mm. According to the surgery table, this deviation should have had a 6mm bimedial rectus recession, equating to a 24$^{\Delta}$ exotropic shift per muscle. The second patient had a deviation of 55$^{\Delta}$ and had bimedial rectus recessions of 7mm, once again too large according to the surgical tables. The third patient had a deviation of 50-55$^{\Delta}$ and had bimedial rectus recessions of 6mm. This was appropriate surgery for this patient, and the patient had a 14$^{\Delta}$ exotropia at 2 years follow-up. The rest of the patients in the partial success group were under corrected with a residual esotropic deviation of 10-20$^{\Delta}$.

In the failed surgery group there were no over corrections, only under corrections. The first patient had a pre-operative deviation of 75$^{\Delta}$. The patient only had 7mm recessions, which is inadequate according to the surgical tables. The patient had a good post-operative angle of 6$^{\Delta}$, but deteriorated to a deviation of 30$^{\Delta}$ esotropia at the 6 months follow up. This patient did not require spectacles. The second failure had a pre-operative deviation of 60$^{\Delta}$ and underwent 7mm recessions which was appropriate. The early post-operative deviation of 14$^{\Delta}$ esotropia, which would generally be a good indicator of orthophoria later on. However, at the 6 month follow-up the deviation was 70$^{\Delta}$ esotropia, larger than the pre-operative deviation of 60$^{\Delta}$. No record was made of a subsequent procedure. The last failure had a pre-operative deviation of 70-75$^{\Delta}$ and underwent 7mm recessions, which is inadequate according to the surgical tables. The post-operative deviation was 45$^{\Delta}$ esotropia that persisted at the 10 month follow up.

A limitation of this study that must be kept in mind is the varying levels of expertise of the surgeons. The procedures were done by registrars and consultants. Registrars were supervised according to their level of seniority. This may have had an affect on the success rate of surgery. However, with a success rate comparable to international studies, this factor may have less of an impact than expected. What probably plays a more important role, is the pre-operative measurement and correct calculation of the amount of recession required. As seen with the partial success group, 2 of the 3 patients that were overcorrected, had incorrect pre-operative calculations done. A further limitation is the absence of records for re-operation. It would be assumed that patients in the partial and unsuccessful groups would have undergone further procedures, but this was not recorded in the orthoptist's register. So the rate of secondary procedures needed would be 23% (n=12). This does not impact this study significantly, as the primary objective was to assess the success of primary surgery.

A selection bias is also inherent to this study design. Finding cases that fulfill all the inclusion and exclusion criteria will garner a patient group with improved compliance and follow up. In this study that may have translated to a better pre-operative measurement, better post-operative follow up and therefore result in better outcomes. In this study only 52 patients out of 475 patients who underwent bimedial rectus recessions for congenital esotropia fulfilled the inclusion criteria, mostly due to inadequate follow up.

The Kruskall-Wallis test was done to compare the success rates in relation to the age of the patient at the time of surgery. The test showed no statistically significant difference in the success rates for different age groups, with a confidence interval of $p=0.06$.

Although it was not the objective of this study, it is interesting to look at the surgical dosages used and relate them to the surgical outcome. This study group was too small to formally draw any conclusions, but as can be seen in Appendix C, patients that had the appropriate surgical dosage in the 50^{Δ} and 60^{Δ} group had a higher success rate. It would be worth carrying out a future study designed and powered to specifically compare the preoperative angle of deviation with surgical dosage and post-operative alignment outcomes.

Conclusion

Congenital esotropia is the most common form of esotropia seen at St John Eye Hospital. It accounts for the vast majority of squint surgery performed at this institution. This study confirms the validity of bimedial rectus recessions as a primary procedure with a high success rate for congenital esotropias of more than 50^{Δ}.

Appendix A: Data Capture Form

<table>
<tr><td>Study Number</td><td colspan="4"></td><td></td><td colspan="2"></td></tr>
<tr><td>Age</td><td colspan="4"></td><td>Sex</td><td>Male</td><td>Female</td></tr>
<tr><td>Race</td><td>B</td><td>W</td><td>I</td><td>C</td><td>Age at the time of surgery</td><td colspan="2"></td></tr>
<tr><td>Pre-surgery maximal angle of esotropia</td><td colspan="4"></td><td>Number of Muscles Operated</td><td colspan="2">Two</td></tr>
<tr><td>Surgical Procedure</td><td colspan="4">BMR</td><td></td><td colspan="2"></td></tr>
<tr><td>Immediate Post Surgery Alignment</td><td colspan="4"></td><td>Alignment at ≥6 months</td><td colspan="2"></td></tr>
<tr><td>Complete Surgical Success</td><td colspan="4">Yes/No</td><td>Partial Surgical Success</td><td colspan="2">Yes/No</td></tr>
<tr><td>Surgical Failure</td><td colspan="4">Yes/No</td><td>Re-operation needed</td><td colspan="2">Yes/No</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td>Notes</td><td colspan="7"></td></tr>
</table>

Appendix B: Cases Summary

Study Number	Age	Sex	Race	Preop Angle	Prodecure	Postop angle	6 Months postop	Success	Spectacles	Follow up
1	6y	F	B	50-55	6mm BMR	20 eso	4-6 eso	Yes	No	7m
2	3y	F	B	60-65	6.5mm BMR	6 eso	8 exo	Yes	No	3y1m
3	1.3y	F	B	50-55	6mm BMR	10 eso	4 eso	Yes	No	3y
4	8y	M	B	75	7mm BMR, BIO Recession	6 eso	30 eso	No	No	6m
5	8y	F	B	60	7mm BMR	14 eso	70-75 eso	No	No	6m
6	3y	F	B	55-60	7mm BMR	12 eso	18 eso	Partial	No	1y
7	22	M	B	70-75	7mm BMR	45 eso	45 eso	No	No	10m
8	5y			55	6.5mm BMR	20-25 eso	0-2 eso	Yes	No	1y5m
9	5y	F	B	50	6.5mm BMR	12 eso	16 exo	Partial	No	1y6m
10	4y	F	B	60-65	7.5mm BMR	14 eso	10 eso	Yes	No	14m
11	4y	M	B	50	6mm BMR	2 eso	2 eso	Yes	No	1y
12	4y	F	B	75	7.5mm BMR	15 eso	4 eso	Yes	No	1y2m
13	3y	M	B	65-70	7.5mm BMR	5 eso	2 eso	Yes	No	1y9m
14	6y	M	B	65	6mm BMR	8-10 eso	8 eso	Yes	No	1y1m
15	11y			50	5.5mm BMR	4-6 eso	2-4 eso	Yes	No	1y10m
16	7y	F	B	60-65	6.5mm BMR	0	4 eso	Yes	No	11m
17	11y	M	B	55	6mm BMR	10 eso	4 eso	Yes	No	1y5m
18	5y	M	B	55	7mm BMR	0	12-14 exo	Partial	No	1y9m
19	12y	M	B	60	7mm BMR	4 eso	10 eso	Yes	No	10m
20	3y	F	B	55	7mm BMR	18 eso	4-6 eso	Yes	No	8m
21	2y	F	B	50	6mm BMR	15 eso	12 eso	Partial	No	6y4m
22	18y	F	B	65-70	7.5mm BMR	18 eso	4-6 eso	Yes	No	6m
23	4y	F	B	50-55	6mm BMR	14 exo	16 exo	Partial	No	2y
24	3y	M	B	55-60	7mm BMR	2 eso	6 exo	Yes	No	2y8m
25	4y	F	B	55-60	7.5mm BMR	30 eso	20 eso	Partial	Yes	1y7m
26	6y	F	B	75	7.5mm BMR	0	18 eso	Partial	No	1y8m
27	2y	M	B	70	7.5mm BMR	0	0	Yes	No	1y7m
28	4y	M	B	80-85	7.5mm BMR	12 eso	8 exo	Yes	Yes	9m
29	8y			50	6.. BMR	0	5 eso	Yes	No	1y1m
30	5y	M	B	55	7mm BMR	14 eso	6 eso	Yes	No	9m
31	4y	M	B	65	7.5mm BMR, BIO Recession	8 eso	0	Yes	No	1y8m
32	1.5y	M	B	55	5mm BMR	5 eso	5 eso	Yes	No	4y10m
33	3y	F	B	65	7.5mm BMR	38-40 eso	10 eso	Yes	No	7m
34	2y	M	B	65-70	7.5mm BMR	12-14 eso	4 eso	Yes	No	2y7m
35	4y	F	B	65-70	8mm RMR Recession, 7.5mm LMR Recession	25 eso	3 eso	Yes	No	9m
36	1.5y			50	6mm BMR	12 eso	4 eso	Yes	No	1y9m
37	3y	M	B	60	7.5mm BMR	4 eso	4 eso	Yes	No	4y4m
38	9y	M	B	60	7.5mm BMR	10 eso	4 eso	Yes	No	9m
39	5y	M	B	65	8mm BMR	16 eso	4 eso	Yes	No	1y3m
40	5y	F	B	55	7.5mm BMR	18-20 eso	12-15 eso	Partial	No	10m
41	2y	F	B	55	6.5mm BMR	8 eso	2-4 eso	Yes	No	4y
42	3y	F	B	70	7.5mm BMR	10 eso	10 eso	Yes	No	4y

Study Number	Age	Sex	Race	Preop Angle	Prodecure	Postop angle	6 Months postop	Success	Spectacles	Follow up
43	3y	F	B	50-55	7mm BMR	10 eso	6 eso	Yes	Yes	2y2m
44	2y	F	B	60	7.5mm BMR	10 eso	6 eso	Yes	No	7m
45	3y	F	B	50	6mm BMR	6-8 exo	5 exo	Yes	No	3y
46	5y	F	B	50	6mm BMR	14 eso	4 eso	Yes	No	8m
47	3y	M	B	60-65	7.5mm BMR, LIO Recession	14 eso	12 eso	Partial	No	1y3m
48	7y	M	B	65	7.5mm BMR	6-8 eso	0	Yes	No	1y4m
49	9y	F	B	50	5.5mm BMR	6 eso	8 eso	Yes	No	9m
50	6y	F	B	70	7mm BMR, BIO Recession	12 eso	4 eso	Yes	No	1y1m
51	3y	F	B	55-60	7mm BMR	8 eso	4 eso	Yes	Yes	5y1m
52	3y	F	B	60	7mm BMR	8 eso	2 eso	Yes	Yes	3y4m

Appendix C: Surgical Success and Dosage

Surgical Success and Dosage				
Pre-operative Deviation	**Dosage of Bimedial rectus recession**	**Result**		
			Number of Patients	Percentage
50 (n=13)	5.5mm	Success	n=2	15%
		Partial Success	n=0	0%
		Failure	n=0	0%
	6.0mm (Appropriate)	Success	n=7	54%
		Partial Success	n=2	15%
		Failure	n=0	0%
	6.5mm	Success	n=0	0%
		Partial Success	n=1	8%
		Failure	n=0	0%
	7.0mm	Success	n=1	8%
		Partial Success	n=0	0%
		Failure	n=0	0%
55 (n=12)	5.0mm	Success	n=1	8%
		Partial Success	n=0	0%
		Failure	n=0	0%
	6.0mm	Success	n=1	8%
		Partial Success	n=0	0%
		Failure	n=0	0%
	6.5mm (Appropriate)	Success	n=2	17%
		Partial Success	n=0	0%
		Failure	n=0	0%
	7.0mm	Success	n=4	33%
		Partial Success	n=2	17%
		Failure	n=0	0%
	7.5mm	Success	n=0	0%
		Partial Success	n=2	17%
		Failure	n=0	0%
60 (n=10)	6.5mm	Success	n=2	20%

Surgical Success and Dosage				
		Partial Success	n=0	0%
		Failure	n=0	0%
	7.0mm	Success	n=2	20%
		Partial Success	n=0	0%
		Failure	n=1	10%
	7.5mm (Appropriate)	Success	n=4	40%
		Partial Success	n=1	10%
		Failure	n=0	0%
65 (n=9)	6.0mm	Success	n=1	12.5%
		Partial Success	n=0	0%
		Failure	n=0	0%
	7.5mm	Success	n=6	75%
		Partial Success	n=0	0%
		Failure	n=0	0%
	8.0mm (Appropriate)	Success	n=1	12.5%
		Partial Success	n=0	0%
		Failure	n=0	0%
70 (n=4)	7.0mm	Success	n=1	25%
		Partial Success	n=0	0%
		Failure	n=1	25%
	7.5mm	Success	n=2	50%
		Partial Success	n=0	0%
		Failure	n=0	0%
75 (n=3)	7.0mm	Success	n=0	0%
		Partial Success	n=0	0%
		Failure	n=1	33%
	7.5mm	Success	n=1	33%
		Partial Success	n=1	33%
		Failure	n=0	0%
80 (n=1)	7.5mm	Success	n=1	100%
		Partial Success	n=0	0%
		Failure	n=0	0%

References

1. Diamond GR. Paediatric and Adult Strabismus. In: Yanoff M, Duker JS, eds. *Ophthalmology*. 3rd ed. St. Louis: Mosby;2008:pages 580-634.
2. Raab E, Aaby A et al. Pediatric Ophthalmology and Strabismus. In: Basic and Clinical Science Course: Section 6. 2011-2012 ed. San Francisco: American Academy of Ophthalmology; 2011-2012:pages 77-108.
3. Hutcheson KA. Childhood esotropia. *Curr Opin Ophthalmol* 2004;15:444-8.
4. Forrest MP, Finnigan S, Finnigan S et al. Three horizontal muscle squint surgery for large angle infantile esotropia. *Clin Exper Ophthalmol* 2003;31:509-516.
5. Calhoun J. Extra-ocular muscle surgery techniques. In: McAllister L eds. Atlas of pediatric ophthalmology surgery.1st ed. Canada: WB Saunders company; 1987:pages1-21.
6. Thomas S, Guha S. Large-Angle Strabismus: Can a single surgical procedure achieve a successful outcome? *Strabismus* 2010;18(4):129-136.
7. Damanakis AG, Arvanitis PG, Ladas ID et al. 8mm Bimedial rectus recession in infantile esotropia of 80-90 prism diopters. *Br J Ophthalmol* 1994;78:842-4.
8. Vroman DT, Hutchinson AK, Saunders RA et al. Two-muscle surgery for congenital esotropia: Rate of reoperation in patients with small versus large angles of deviation. *J AAPOS* 2000;4(5):267-270.
9. Rowe FJ. Long-term post-operative stability in infantile esotropia. *Strabismus* 2000;8(1): 3-13.
10. Szmyd SM, Nelson LB, Calhoun JH et al. Large bimedial rectus recessions in congenital esotropia. *Br J Ophthalmol* 1985;69:271-4.
11. Nelson LB, Calhoun JH, Simon TW et al. Surgical management of large angle congenital esotropia. *Br J Ophthalmol* 1987;71:380-3.

12. Weakley DR, Stager DR, Everett ME. Seven-millimeter bilateral medial rectus recessions in infantile esotropia. *J Ped Ophthalmol Strab* 1991;28:113-5.

13. Scott WE, Reese PD, Hirsch CR et al. Surgery for large angle congenital esotropia. *Arch Ophthalmol* 1986;104:374-7.

14. Lee DA, Dyer JA. Bilateral medial rectus muscle recession and lateral rectus muscle resection in the treatment of congenital esotropia. *Am J Ophthalmol* 1983;95:528-35.

15. Hess JB, Calhoun JH. A new rationale for the management of large angle esotropia. *J Ped Ophthalmol Strab* 1979; 16(6):345-8.

R14/49 Dr Roland Hollhumer

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M130943

NAME: (Principal Investigator) Dr Roland Hollhumer

DEPARTMENT: Ophthalmology
St Johns Eye Hospital
Chris Hani Baragwanath Academic Hospital

PROJECT TITLE: A Retrospective Review of Ocular Alignment after Large Angle Congenital Esotropia Surgery

DATE CONSIDERED: 27/09/2013

DECISION: Approved unconditionally

CONDITIONS:

SUPERVISOR: Dr B Vallabh

APPROVED BY: _____
Professor PE Cleaton-Jones, Chairperson, HREC (Medical)

DATE OF APPROVAL: 18/10/2013

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Secretary in Room 10004, 10th floor, Senate House, University.
I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**.

_____ _____
Principal Investigator Signature Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES