African Vision and Eye Health
ISSN: (Online) 2410-1516, (Print) 2413-3183

Intramuscular Botulinum Neurotoxin Injections for Infantile Esotropia: A Durban Academic Hospital Review

Authors:
Mohammed Khan[1]
Anine Kritzinger[1]

Affiliations:
[1]Discipline of Ophthalmology, School of Medicine, University of KwaZulu-Natal, Durban, South Africa

Corresponding author:
Mohammed Khan,
lightymo@gmail.com

Dates:
Received: 10 Sept. 2024
Accepted: 01 Dec. 2024
Published: 25 Feb. 2025

How to cite this article:
Khan M, Kritzinger A. Intramuscular Botulinum Neurotoxin Injections for Infantile Esotropia: A Durban Academic Hospital Review. Afr Vision Eye Health. 2025;84(1), a994. https://doi.org/10.4102/aveh.v84i1.994

Background: Infantile esotropia is characterised by a constant, large-angle strabismus present before 6 months of age. Botulinum neurotoxin (BNT) injections offer a potential alternative to surgical correction.

Aim: To evaluate the effectiveness and safety of bilateral medial rectus BNT injections in managing infantile esotropia in children younger than 2 years.

Setting: The study was conducted at a quaternary hospital in KwaZulu-Natal, South Africa.

Methods: A retrospective chart review was performed for patients who received bilateral medial rectus BNT injections over a 7-year period. The primary outcome was the change in the angle of deviation from baseline to 6 months post-treatment. Success was categorised as complete, partial or qualified. Secondary outcomes included complications and demographic factors.

Results: The study assessed 41 patients. Most patients were African (90.20%) with large-angle esotropia (85.20%). The mean pre-treatment angle of deviation in the study population was 64.00 prism dioptres (PD). This decreased to a mean post-treatment angle at 6 months of 31.40 PD. There were 28 successes (68%) at 6 months, which comprised 18 patients (43.9%) who had complete or partial success and 10 patients (24.4%) with qualified success.

Conclusion: Botulinum neurotoxin injections can be considered as a first-line treatment for infantile esotropia in patients under 2 years, regardless of the initial angle of deviation and are effective and safe.

Contributions: Botulinum neurotoxin injections offer a viable alternative to surgery in resource-constrained settings where theatre time may be limited.

Keywords: strabismus; infantile esotropia; botulinum neurotoxin; chemo-denervation; non-surgical intervention; paediatric ophthalmology; cost-effectiveness.

Introduction

Infantile esotropia is defined as an esotropia that is present before the age of 6 months, with a constant, large-angle of strabismus.[1] Globally, childhood strabismus is encountered in ophthalmology outpatient clinics with a prevalence of 2.1% in the general population. The prevalence of infantile esotropia can range from 1 in 403 to 1 in 50 children.[2,3] In South Africa, large-angle infantile esotropia (> 50 PD [prism dioptres]) is commonly seen and is substantially more prevalent than accommodative esotropia in African patients.[4]

Most South African children with strabismus present prior to the age of 2 years, which is an important time for the development of stereopsis.[4] A study conducted by Ing highlighted the importance of surgical correction by 2 years of age to optimise binocular function.[5] More recent findings suggest earlier intervention is beneficial. For instance, a 2014 study by Çerman et al. found that aligning infants with esotropia by 16 months of age significantly enhances the chances of achieving measurable stereopsis.[6] Further, a 2020 study by Yagasaki et al. demonstrated that very early surgery, performed at or before 8 months of age, markedly improves the likelihood of postoperative stereopsis,[7] emphasising the importance for early intervention.

In infantile esotropia, surgical correction with bilateral medial rectus recession procedure is the standard of care and has a success rate of 75% – 80%.[8] The average surgical time is approximately

1 h,[9] and in larger angle esotropias, multiple operations are often required to achieve a desirable ocular motor outcome.[10]

An alternative treatment method is botulinum neurotoxin (BNT) injection to the medial rectus muscles, which has been shown to be a valuable alternative to strabismus surgery in infantile esotropia, particularly in the case of small-moderate deviations(<50 PD).[11,12,13,14] Botulinum neurotoxin is a potent toxin that produces paralysis by blocking the presynaptic release of acetylcholine at the neuromuscular junction. This process is a reversible chemical denervation resulting in a transient muscular paralysis.[15,16] The effect produced at the neuromuscular junction usually resolves by 3 months, while successful ocular alignment or reduction in the magnitude of the strabismic deviation may persist indefinitely. This change in muscle architecture as well as proprioceptive and binocular factors contributes to the long-term improvement in alignment of strabismus patients, even after the pharmacologic effects of BNT have ended.[17]

South African studies have shown that BNT injections have a cost–benefit advantage over surgery and can be used as a viable option in infants less than 2 years of age with infantile esotropia.[9] These injections reduce time in theatre as compared to surgery and are associated with less acute pain and a shorter predicted time in hospital.[9]

In a resource-constrained setting such as South Africa, with theatre time limitations and the significant cost associated with longer hospital stays, BNT injections may be considered a first-line option in a select group of patients with infantile esotropia.

The objective of this study was therefore to determine whether BNT should be considered as a first-line treatment for infantile esotropia in a South African population where most patients present with large-angle deviations. Thus, this study aimed to look at the safety and effectiveness of BNT as the first-line treatment for infantile esotropia in patients under 2 years of age who presented to a quaternary hospital in Durban, KwaZulu-Natal between 01 January 2016 and 31 December 2022.

Research methods and design

Study design

This study utilised a retrospective observational design. The study was chosen because of the lack of current data on the use of BNT in infantile esotropia, particularly on infants less than 18 months in resource-constrained settings such as South Africa. A retrospective chart review of all 63 patients who underwent bilateral medial rectus neurotoxin injections for infantile esotropia at Inkosi Albert Luthuli Central Hospital (IALCH) over a 7-year period was done. The standalone procedure was performed by the senior registrar and consultant ophthalmologists at IALCH.

Surgical procedure

The standard surgical procedure for infantile esotropia was carried out in all patients reviewed as per practice guidelines at the facility. All patients received bilateral injections of 5 IU of botulinum toxin type A (Botox®, Allergan, Irvine, Calif) in 0.1 mL of saline administered with a 27-gauge needle on an insulin syringe without electromyographic (EMG) guidance under general anaesthesia, without conjunctival incision. The duration of the entire procedure, from the start of anaesthesia to completion averaged at less than 30 min.

Study population and sampling strategy

A total of 63 patients underwent BNT at IALCH between 01 January 2016 and 31 December 2022. A total of 22 patients were then excluded from the study with 11 being lost to follow-up and a further 11 meeting the exclusion criteria as listed next. The final analysis consisted of 41 patients.

Inclusion criteria

The study included all patients with infantile esotropia with an angle of deviation > 30 PD that were treated at the facility between the ages of 6 months and 2 years with BNT injections.

Exclusion criteria

Patients were excluded from the study if they had underlying neurological conditions, significant deviations in A or V patterns, or significant refractive errors. Significant refractive error was defined in the study as hypermetropia greater than +4.00 dioptres, astigmatism more than 1 dioptre and myopia of –5.00 dioptres. In addition, those with evidence of amblyopia, a history of strabismus surgery or incomplete information were also excluded.

Study outcome measures

Primary outcome measures

The primary outcome measure was the 6-month post-procedural change in the angle of deviation from baseline measured in PD.

Success was divided into three categories as follows:

1. *Complete success* – Patients who had no residual strabismus or were noted to have a small angle of deviation measuring < 10 (PD) (esotropia or exotropia) after BNT at the follow-up visit.
2. *Partial success* – Patients with a small angle of residual esotropia, an angle measuring between 10 PD and 20 PD (10 PD < angle < 20 PD).
3. *Qualified success* – Patients noted to have a decrease in their angle of deviation from > 50 PD to < 50 PD esotropia but still with esotropia > 20 PD.

Non-success included patients that did not meet the above criteria, had < 10 PD improvement in their angle of deviation or were still noted to have > 50 PD esotropia or any patients that underwent surgical correction in the first 6 months post procedure.

Secondary outcome measures

The inclusion of secondary outcome measures was defined by a measure meeting one or all of the following:

1. Factors that improve the likelihood of success.
2. Factors that contribute to an unsuccessful outcome
3. Complications that occurred post procedure.

Patient and demographic factors that were assessed in the study included gender, race, age, presenting angle, months to first injection and number of injections at 6 months post initial intervention.

Data collection procedure

Data collection and collation was conducted by the principal investigator (M.K.) over a period of 3 months. All patient details were collated using a data collection sheet and the information obtained was captured onto an Excel® spreadsheet.

Pre-operative clinical and demographic data including age at first presentation, race, gender, angle of deviation at first presentation, presence of a fixation preference, fundoscopic exam, cycloplegic refraction and a birth and medical history were obtained from the chart reviews. Participants were reviewed at 1 week, 3 months, 6 months and 1 year post-treatment with documentation of their angle of deviation as well as any post-procedural complications noted.

Statistical methodology

IBM SPSS (Statistical Package for the Social Sciences) version 28 (Armonk, New York, United States) was used to analyse the collected data. Descriptive statistics such as mean, standard deviation (s.d.) and range were used to summarise continuous data, which were normally distributed, and median and inter-quartile range (IQR) were used for not normally distributed data. Categorical data were described using frequencies and percentages. The difference between the angles at presentation, 3 months and 6 months were compared using Related-Samples Friedman's Two-Way analysis of variance (ANOVA) by ranks test. Three- and 6-month binary outcomes were compared using paired McNemar's test, and factors associated with success were assessed using Pearson's chi square test or Fisher's exact tests as appropriate. The statistical significance level (*P*-value) used was 0.05.

Ethical considerations

The study protocol was granted full ethical approval by the Biomedical Research Ethics Committee at UKZN (BREC/00005247/2023). Approval of KwaZulu-Natal Department of Health (DOH) and permission of the facility gatekeeper was obtained. Access to medical records was then granted by the medical manager at the facility in which the study was conducted. Patients were identified using hospital numbers and remained anonymous throughout the course of the study.

Results

The study analysed a total of 41 patients. The average age at presentation was 11.17 months, with the youngest participant aged 6 months and the oldest aged 18 months. At the time of intervention, the mean age was recorded at 11.76 months. The demographic data of the sample are detailed in Table 1; among the participants, there were 27 females (65.9%) and 37 Africans (90.2%). A substantial majority of patients ($n = 35$, 85.4%) had an angle of deviation > 50 PD. Furthermore, 95% of the patients received a single injection, while 5% received two injections before their assessment at the 6-month mark.

The mean pre-treatment angle of deviation in the study population was 64.0 PD (Table 2). This decreased to a mean post-treatment angle at 3 months of 23.4 PD and thereafter increased to 31.4 PD at the 6-month follow-up visit (Table 2). The values decreased overall between pre-treatment and 6 months ($p < 0.001$). Post hoc tests showed that the difference was significant between pre-treatment and 3 months, as well as pre-treatment and 6 months, but the change in angle between 3 and 6 months was not statistically different.

Figure 1 shows the distribution of values pre-treatment, 3 months and 6 months after treatment. There is a large decrease in values between pre-treatment and 3–6 months. The values decreased statistically significantly overall between pre-treatment and 6 months ($p < 0.001$).

At 3 months post Botox, 29.3% had complete response (< 10 PD angle esotropia), which declined to 14.6% after 6 months. At 3 months post Botox, 14.6% had no response, which increased to 31.7% by 6 months Table 3. Partial and minimal response percentages did not change significantly between 3 and 6 months.

Success was defined as any response other than no response (complete, partial and minimal response) 6 months post initial intervention. There were 35 successes (85.4%) at 3 months and 28 (68.3%) at 6 months.

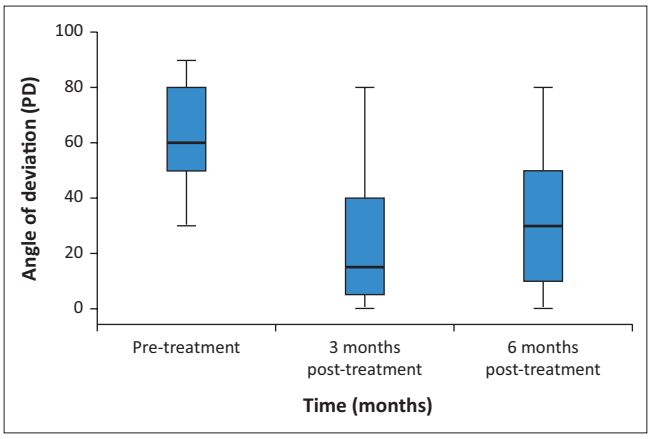
TABLE 1: Patient demographics.

Participant demographic	*n*	%
Gender		
Female	27	65.9
Male	14	34.1
Race		
African people	37	90.2
Mixed-race people	2	4.9
Indian people	2	4.9

TABLE 2: The angle of strabismus in prism dioptres before and after botulinum neurotoxin treatment.

Descriptive measures	Pre-treatment	3 months post-treatment	6 months post-treatment
Mean	64	23.4	31.4
Median	60	15	30
Max	90	80	80
Min	30	0	0

Max, maximum; Min, minimum.



PD, prism dioptres.

FIGURE 1: Box and whisker plot of deviation values pre-treatment, 3 and 6 months after treatment.

TABLE 3: Percentage of successful and unsuccessful cases with success divided into 'qualified, partial and complete success''.

Categories of success	Pre-treatment (%)	3 months post-treatment (%)	6 months post-treatment (%)
Unsuccessful	100	14.6	31.7
Qualified success	0	24.4	24.4
Partial success	0	31.7	29.3
Complete success	0	29.3	14.6

TABLE 4: Factors associated with successful outcome.

Demographic factors	Success at 6 months post-treatment						*P*
	No success		Success		Total		
	n	%	*n*	%	*N*	%	
Gender	13	100.0	28	100.0	41	100.0	0.756
Female	9	69.2	18	64.3	27	65.9	-
Male	4	30.8	10	35.7	14	34.1	-
Race	13	100.0	28	100.0	41	100.0	0.385
Black people	13	100.0	24	85.7	37	90.2	-
Coloured people	0	0.0	2	7.1	2	4.9	-
Indian people	0	0.0	2	7.1	2	4.9	-
Age group (months)	13	100.0	28	100.0	41	100.0	0.734
≤ 12	9	69.2	17	60.7	26	63.4	-
12–24	4	30.8	11	39.3	15	36.6	-
Presenting angle (PD)	13	100.0	28	100.0	41	100.0	0.645
< 50	1	7.7	5	17.9	6	14.6	-
≥ 50	12	92.3	23	82.1	35	85.4	-

PD, prism dioptres.

At the 6-month follow-up visit, the successes were composed of 18 patients (43.9%) who had complete or partial success representing a residual angle of < 20 PD (Figure 2). The remaining 10 patients (24.4%) were classified as qualified success indicating a change in esotropia from ≥ 50 PD to < 50 PD.

In the 1-year follow-up group, it was noted that 12 patients had another intervention after 6 months with 3 more patients having a repeat BNT injection and 9 patients undergoing surgical correction. In total, 14 patients (34.1%) received a second intervention within the first year.

None of the factors considered were statistically significantly associated with a greater chance of a successful outcome. More than 60% of the participants were under 12 months in both groups (success and no success) and the presenting angle was ≥ 50 PD in both groups (Table 4). The sample size was too small to detect moderate and small difference between groups to be statistically significant.

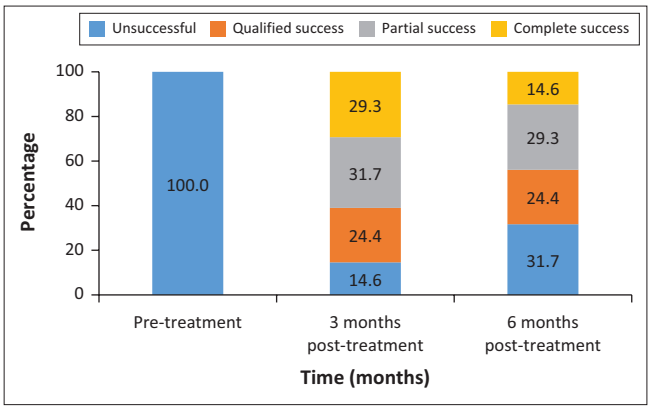


FIGURE 2: Percentage of 'successful' and 'unsuccessful' cases at 0, 3 and 6 months divided into categories of success.

Analysis of variance

No pre-, intra- or persistent postoperative complications were recorded. A mild ptosis caused by spread of the BNT to the levator muscle was seen in 10 of the 41 (21.4%) injections. No cases of deprivation amblyopia were noted. Two patients were reported to have red and itchy eyes post-procedure, which resolved without treatment and one case of pre-septal cellulitis was observed at the 3-month follow-up visit. Furthermore, 10 patients (24.4%) developed inferior oblique overaction (IOOA) and 1 patient (2.4%) developed a dissociated vertical deviation (DVD) during the study period. There were no adverse events reported in 41.5% of patients (Table 5).

Discussion

In this retrospective review, we evaluated the efficacy of BNT injections as a first-line treatment for infantile esotropia among patients at a quaternary hospital in KwaZulu-Natal, South Africa. Our cohort comprised of 41 patients, with 26 (63%) receiving their initial injection prior to 12 months of age and a notable 35 patients (85.4%) presenting with an angle of deviation greater than 50 PD. These findings are consistent with previous studies conducted in the region, including Du Bruyn et al., which reported mean pre-operative angles of esotropia between 77 PD and 82 PD.[18] This prevalence of large-angle (> 50 PD) congenital esotropia aligns with observations in diverse populations, particularly African patients[4] and reinforces the need for tailored treatment strategies including initial intervention with BNT.

Both local and international studies report comparable success rates for BNT injections to surgical interventions when deployed as the primary treatment for infantile esotropia.[11,12,13,14,19,20,21,22,23] For instance, De Alba Campomanes et al. compared BNT injections with surgery as the primary treatment of infantile esotropia and reported a success rate of 45% after a mean number of 1.6 injections. Success in Campomanes et al.'s study was noted as a decrease in angle

TABLE 5: Complications noted after botulinum neurotoxin procedure.

Adverse events	*n*	%
Inferior oblique overaction	10	24.4
Itching and or red eyes	2	4.9
Left DVD	1	2.4
Ptosis	10	24.4
Pre-septal cellulitis at 3 month visit	1	2.4
None	17	41.5
Total	**41**	**100.0**

DVD, dissociated vertical deviation.

to < 10 PD compared to complete success in our study. De Alba Campomanes et al. also analysed the success rate considering initial angle of deviation (smaller or larger than 30 PD), which showed better success rates in smaller deviations (59%) than in larger angle esotropias (36%).[13] McNeer et al. reported that patients who received BNT injections before 12 months of age (mean 7.8 months) had a success rate of 93%, while patients older than 12 months (mean 25.6 months) had a success rate of 86%. In McNeer's study, BNT reduced the mean pre-injection deviation of 33 PD to an average esotropia angle of 2 PD.[11] Our study had a substantially larger mean pre-injection deviation (64.00 PD), which may have contributed to the larger post-procedure deviation obtained at the 6-month follow-up (31.40 PD).

Currently, there are no guidelines regarding the use of BNT in the treatment of infantile esotropia. This is echoed in the literature where various articles reported different methods of BNT injections.[14] In the study conducted by Scott et al., BNT doses of 1–2.5 IU were used based on the degree of deviation. If a subsequent injection was required, the dose was increased up to double the prior dose.[22] De Alba Campomanes et al. utilised injections of 5 IU of botulinum toxin in deviations of less than 50 PD and 7.5 IU in deviations greater than 50 PD,[13] whereas McNeer et al. injected a standard 2.5 IU of botulinum toxin with the use of an EMG monitor. Campos et al. was the only study where BNT injections were performed under direct visualisation of the rectus muscles with an 'open sky' technique.[20] In our study, all patients received bilateral injections of 5 IU of botulinum toxin type A (Botox®, Allergan, Irvine, Calif) in 0.1 mL of saline without EMG guidance under general anaesthesia and without conjunctival incision. The differences in injection techniques and quantity of BNT administered may be one of the reasons for the different success rates encountered throughout the literature, thus making it difficult to draw direct comparisons between these studies highlighting the need for establishing a standard best practice in BNT treatment.

The majority of patients (n = 36, 87.8%) in the study received only a single BNT injection during the study period, with 5 patients (12.2%) receiving a second injection within the initial 6 months. Comparatively, previous studies, including those by McNeer et al. and De Alba Campomanes et al., reported higher rates of multiple injections required for successful outcomes.[11,13] In McNeer et al.'s study, 53.0% patients required only 1 bilateral injection while De Alba Campomanes et al. showed that 48.7% (n = 157) received a single injection, 40% (n = 132) received two injections and 10.2% (n = 33) received three injections. This disparity potentially contributed to the lower complete and partial success rates observed in our study (43.9%) compared to McNeer et al. and De Alba Campomanes et al.'s studies that reported success rates of 45% and 89%, respectively. Subsequent injections have been shown to lead to more significant reductions in the angle of deviation.

Campos et al. had the best success rate of 88% after a single BNT injection. In their study, the mean age at injection was 6.5 months, which was markedly lower than our study with the mean age at intervention being 11.76 months.[20] This emphasises the importance of timing and initial treatment strategies. Notably, at the IALCH Paediatric Ophthalmology clinic, parents were informed of the potential need for a second BNT injection. However, it is noted that in some cases parents directly requested surgical intervention, indicating a potential preference for surgical rather than pharmacological options in certain instances.

Traditionally, horizontal extraocular muscle surgery has been the preferred method for managing infantile esotropia, with an overall success rate of 75% – 80%.[8] However, it has been documented that a significant proportion of surgical patients (35% – 50%)[24] may require additional corrections post-operatively, particularly in cases of larger angle deviations.[25] Our study aimed to explore BNT as a viable alternative, particularly in managing predominantly large-angle esotropias.

The historical backdrop of BNT in strabismus treatment began with Scott's pioneering work in 1981, demonstrating the potential of BNT as surgical adjuncts or alternatives.[22] In his study, the maximum correction of strabismus was found to be 40 PD and the duration of action lasted up to 6 months. Subsequent studies have confirmed its efficacy, reporting correction of esotropia angles up to 90 PD and reductions exceeding 50% following initial injections.[12,13,19] Our findings further substantiate this trend, with pre-treatment angles decreasing significantly from a mean of 64.00 PD to 31.40 PD post-injection.

The percentage of complete and partial responses to BNT injections observed in the study was 14.6% and 29.3%, respectively (overall 45.9%). This is similar to a South African study conducted by Mayet et al., which noted a 50% overall overall response rate (defined as < 20 PD residual esotropia).[12] De Alba Campomanes et al. also noted a similar success rate of 36.0% in large-angle esotropias treated with BNT although they qualified success as < 10 PD.[13] In a meta-analysis by Issaho et al., the success rate of BNT ranged from 37.5% to 100.0%.[14] Small to moderate angles of esotropia (< 30 PD) were generally associated with higher success rates while studies of large angles reported lower rates of success. This could explain the relatively low number of complete and partial successes (43.9%) noted in our study as 35 patients (85.4%) had large-angle (> 50 PD) esotropias on initial presentation.

Bilateral BNT injections have gained acceptance as an alternative to surgery for congenital esotropia with small to moderate deviations (< 50 PD).[12,13,21,26] A 2024 study by Claude-Speeg-Schatz et al. concluded that, should additional surgery be required (49% in their series), initial BNT injections allowed the procedure to be carried out on a smaller angle.[23] Several studies have indicated that smaller pre-operative angles are usually associated with favourable motor outcomes and a lower reoperation rate.[18,25,27,28] Ten patients (24.4%) in our study population had an esotropia that decreased from > 50 PD to < 50 PD and were classified as minimal/qualified success because of the likelihood of a more successful second procedure in the form of surgery. This often overlooked benefit is even more important in resource-constrained populations such as sub-Saharan Africa where theatre time is limited and patients are less likely to have access to healthcare facilities for additional surgeries.[29]

Our study also underscores significant implications for resource-limited settings where access to surgical interventions may be constrained. Botulinum neurotoxin as an initial therapy reduces the need for more extensive surgical procedures, allowing for timely management in populations that face delays typical in accessing elective surgeries. Botulinum neurotoxin injections can potentially facilitate earlier remediation in esotropia, providing patients with enhanced opportunities for developing binocular vision.

In our study, 63.4% of patients were aged less than 1 year with 18 patients (43.9%) aged 10 months or less. A previous South African study on BNT treatment in infantile esotropia by Mayet et al. did not recruit any infants < 10 months making this the first study including this cohort (< 10 months) in South Africa. Mayet et al. concluded that BNT has a cost–benefit in infantile esotropia and is a viable option in the primary treatment of IE in resource-constrained regions. Their study noted that patients with large-angle esotropia (noted in their study to be < 60 PD) fared worse than smaller angles.[9,12] Our study did not find a statistically significant difference in success between patients with deviations greater and less than 50 PD (P = 0.645) or in those aged greater or less than 12 months (P = 0.734). This may be because of the significant numbers of large angles and children less than 12 months or the added measure of qualified success included in this study.

Multiple studies have reported the relationship between early intervention and the development of stereopsis in patients with infantile esotropia.[5,6,7] In developing countries such as, South Africa, access to theatre is often limited and patients often wait up to 6 months for elective general anaesthetic procedures. Time spent in theatre was noted to be the greatest cost factor and surgery took six times longer than injections according to Mayet.[9] In our study, bilateral BNT injections took an average of 12 min per patient, substantially less than the surgical alternative. Botulinum neurotoxin injections therefore reduce theatre time and allows earlier theatre access to a greater number of patients offering patients a better chance for binocular vision and stereopsis.

The secondary outcome measures of the study sought to identify patient factors associated with a greater rate of successful outcome as well as looking at the complications of the procedure. None of the factors considered were statistically significantly associated with success. There was no significant difference in achieving success between the male and female groups (P = 0.756). There were mostly African participants in both success and non-success groups (85.7% and 100.0%, respectively). More than 60.0% of participants were under 12 months in both successful and unsuccessful groups (69.2% and 60.7%, respectfully). The presenting angle was > 50 PD in both groups (mean 64 PD), and there was no difference in success between the large-angle (> 50 PD) or smaller angle cohort (P = 0.645). A slightly smaller percentage of the success group had more than one injection (7.0% vs 23.0%), but this difference was not statistically significant (P = 0.304). The sample size was likely too small to determine that factors were more likely to lead to a successful outcome after BNT injection.

Botulinum neurotoxin injection into the medial recti muscles is a safe and quick procedure that offers a valuable alternative to strabismus surgery in congenital esotropia.[11,13,19,26] The most common side-effect encountered in our study was a mild ptosis in 10 patients (24.4%). There were no cases of significant or complete ptosis resulting in occlusion of the visual axis. Two patients (4.9%) developed itchy, red eyes and one case of pre-septal cellulitis (2.4%) was noted at the 3-month follow-up. All complications were transient and reversible, and there were no long-term complications observed at the 6-month follow-up visit. A further 10 patients (24.4%) developed IOOA and 1 patient (2.4%) developed a DVD during the study period. These are thought to be in keeping with the natural history of infantile esotropia syndrome rather than a complication of BNT treatment. The study did not have a long enough follow-up period to report on secondary surgeries needed for oblique muscle overactions. A repeat refraction was not performed to look at worsening or the development of significant hyperopia, which has been reported in previous studies.[11,19]

The one-year follow-up records included 32 patients who were neither lost to follow-up nor excluded for any reason. The success or non-success of these patients fell outside the prescribed outcome measures of the study. By 1 year, a further 10 patients had another intervention after 6 months (three repeat BNT and seven surgeries) and 18 out of 32 patients (56.3%) were aligned within 20 PD. The timing of development of IOOA or DVD was not recorded in the study.

A 2023 Cochrane review by Mehner et al. showed that the evidence supporting medial rectus recessions over BNT injections was very uncertain.[30] Further research through larger, randomised controlled trials and prospective studies with extended follow-up periods are warranted to comprehensively evaluate the long-term efficacy of BNT and to clarify which patient demographics may derive the greatest benefit from this approach. This could support the inclusion of qualified success, as it is currently unknown whether BNT

injections will lead to lower reoperation rate for patients with large-angle infantile esotropia. Stereopsis testing as soon as patients can provide acceptable responses should be employed to further support the use of BNT injections as a means of earlier treatment in parts of the world where access to theatre is limited. These studies could also include follow-up refractions and monitor the development of oblique muscle overactions and DVDs as some literature has noted that early intervention may alter the development of these complications.[25]

Limitations

The study was a retrospective review of patients and includes all of the limitations inherent to this type of study. Most patients (90.2%) were African therefore it is unclear whether this study could apply to other cohorts. The benefit of qualified success, as defined in this study, has yet to be proven in a long-term randomised controlled study. The short follow-up period of 6 months after the last injection does not allow us to account for long-term complications such as late esodeviation or the development of hyperopia. Stereopsis testing and repeat refractions were not performed. Although all injections were performed under the supervision of a specialist working in the Paediatric Ophthalmology Unit, different surgeons and examiners were involved in the care and assessment of patients.

Conclusion

The findings in this study indicate that bilateral medial rectus BNT injections can be considered as a potential first-line intervention for infantile esotropia in all patients under 2 years of age regardless of their angle of deviation. Botulinum neurotoxin injections are considered an effective and safe treatment of essential infantile esotropia and offer a valuable alternative to strabismus surgery in developing countries where resources are limited with respect to the waiting time for surgery. Long-term randomised controlled and prospective clinical trials are required to establish the benefit of qualified success after BNT injections and compare it to surgical intervention as a first-line intervention for large-angle esotropias.

Acknowledgements

The authors thank Dr. Magritha du Bruyn for her guidance as well as assistance in the editing of this article. The authors would also like to thank Dr. Nabeela Kajee for her assistance in editing and Professor Tonya Esterhuizen for her input and statistical analyses.

Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contributions

M.K. contributed to the conceptualisation and design of the study, data collection and analysis and write-up of the article. A.K. contributed to the conceptualisation and design of the study, data analysis, review of the article and supervision of the project.

Funding information

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Data availability

The data that support the findings of this study are available from the corresponding author, M.K. upon reasonable request.

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