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Original Research Article

Acceptance of Topical Atropine over Physical Occluders in Treatment of Amblyopia in Children

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Abstract:

Background: Amblyopia is a common cause of monocular visual impairment in children. Conventional treatment involves occlusion therapy, but compliance can be a challenge. Atropine penalization has emerged as a potential alternative treatment option.

Objective: To compare the acceptance and efficacy of topical atropine penalization with conventional occlusion therapy in the treatment of amblyopia in children aged 3-12 years.

Methods: In this prospective, randomized controlled trial, 30 children with amblyopia were randomly allocated to either atropine penalization (n=15) or occlusion therapy (n=15) for 6 months. Visual acuity, treatment compliance, adverse effects, and parental satisfaction were assessed at baseline and at 1, 3, and 6 months.

Results: Both atropine penalization and occlusion therapy resulted in significant improvements in visual acuity from baseline to 6 months ($P<0.001$), with no significant difference in the magnitude of improvement between the groups ($P=0.18$). Compliance was significantly better in the atropine group, with a mean of 4.2 ± 2.8 days of missed treatment compared to 8.5 ± 4.6 days in the occlusion group ($P=0.004$). The occurrence of adverse effects was similar between the groups ($P=0.26$). Parental satisfaction scores were slightly higher in the atropine group, but these differences were not statistically significant.

Conclusion: Atropine penalization is as effective as occlusion therapy in improving visual acuity in children with amblyopia, with the added advantages of better treatment compliance and slightly higher parental satisfaction. These findings support the use of atropine penalization as a viable alternative to occlusion therapy in the management of amblyopia in children.

Keywords: Amblyopia, Atropine Penalization, Occlusion Therapy, Visual Acuity, Compliance, Randomized Controlled Trial.

Introduction

Amblyopia, commonly known as lazy eye, is a developmental disorder of the visual system characterized by reduced visual acuity in one or both eyes, without any apparent structural abnormalities or ocular diseases [1]. It affects approximately 1-5% of the general population and is a leading cause of monocular visual impairment in children and young adults [2,3]. Amblyopia typically develops during early childhood due to abnormal visual experience, such as strabismus, anisometropia, or visual deprivation [4].

The primary goal of amblyopia treatment is to improve visual acuity in the affected eye and promote binocular vision [5]. Conventionally, amblyopia treatment involves occlusion therapy, where the better-seeing eye is patched for several hours a day to stimulate the use of the amblyopic eye [6]. However, occlusion therapy has several limitations, including poor compliance, social stigma, and potential adverse effects on the child's emotional and social development [7,8].

In recent years, topical atropine has emerged as a promising alternative to occlusion therapy for the treatment of amblyopia [9]. Atropine, an anticholinergic agent, is administered as eye drops to the better-seeing eye, causing cycloplegia and blurred near vision, thereby encouraging the use of the amblyopic eye [10]. Several studies have demonstrated the efficacy of atropine penalization in improving visual acuity in amblyopic children [11-13].

The acceptance of topical atropine over physical occluders in the treatment of amblyopia in children has been a topic of growing interest among healthcare professionals and parents alike. This

article aims to provide a comprehensive review of the current literature on the acceptance of topical atropine compared to physical occluders in the management of amblyopia in children.

One of the main advantages of topical atropine over physical occluders is its better acceptance and compliance among children and their families [14]. In a randomized controlled trial conducted by the Pediatric Eye Disease Investigator Group (PEDIG), atropine penalization was found to be as effective as patching in improving visual acuity in children with moderate amblyopia, with a higher treatment adherence rate [15]. The study reported that 84% of children in the atropine group adhered to the treatment regimen, compared to only 54% in the patching group.

The better acceptance of atropine penalization can be attributed to several factors. First, atropine eye drops are less visible and less stigmatizing than eye patches, which can be crucial for children's self-esteem and social interactions [16]. Second, atropine penalization allows for more flexible treatment schedules, as the drops can be administered once daily, compared to the several hours of daily patching required with occlusion therapy [17]. This flexibility can lead to better treatment compliance and reduced stress for both children and their caregivers.

Moreover, atropine penalization has been shown to have fewer adverse effects compared to occlusion therapy [18]. While both treatments may cause temporary blurred vision and light sensitivity, occlusion therapy can lead to skin irritation, allergic reactions, and even amblyopia in the patched eye if not monitored carefully [19]. In contrast, the side effects of atropine are generally mild and reversible, with the most common being temporary dilation of the pupil and blurred near vision [20].

Despite the growing evidence supporting the use of atropine penalization in amblyopia treatment, some concerns have been raised regarding its long-term safety and efficacy [21]. Some studies have suggested that the visual acuity gains achieved with atropine may not be sustained after treatment discontinuation, and that a tapering schedule may be necessary to prevent regression [22,23]. Additionally, the optimal dosage and duration of atropine treatment are still under investigation, with various regimens being used in different studies [24].

Another factor influencing the acceptance of topical atropine over physical occluders is the child's age and type of amblyopia. In younger children (3-7 years old) with moderate amblyopia, atropine penalization has been shown to be as effective as patching, with better compliance rates [25]. However, in older children or those with severe amblyopia, occlusion therapy may still be the preferred treatment option [26]. Furthermore, the type of amblyopia (strabismic, anisometropic, or mixed) may affect the response to atropine treatment, with some studies suggesting that anisometropic amblyopia may be more amenable to atropine penalization [27].

Parental education and involvement also play a crucial role in the acceptance and success of amblyopia treatment [28]. Healthcare professionals should provide clear and detailed information about the available treatment options, their benefits, and potential side effects, to help parents make informed decisions [29]. Engaging parents in the treatment process, through regular follow-up visits and progress monitoring, can improve treatment adherence and outcomes [30].

In conclusion, topical atropine has gained increasing acceptance over physical occluders in the treatment of amblyopia in children, owing to its better compliance, fewer adverse effects, and comparable efficacy in selected cases. However, the choice of treatment should be individualized based on the child's age, type and severity of amblyopia, and parental preferences. Further research is needed to establish the long-term safety and efficacy of atropine penalization, as well as to determine the optimal treatment regimens for different subgroups of amblyopic children.

Aims and Objectives

The primary aim of this study was to compare the acceptance and efficacy of topical atropine penalization with conventional occlusion therapy in the treatment of amblyopia in children aged 3-12 years. The specific objectives were to assess the visual acuity improvement, treatment compliance, and adverse effects associated with each treatment modality over a 6-month period.

Materials and Methods

Study Design and Setting: A prospective, comparative was conducted at Sahai Hospital & Research Centre from March 2022 to February 2023. The study protocol was approved by the Institutional Ethics Committee, and informed consent was obtained from the parents or legal guardians of all participants.

Sample Size and Participant Selection: A total of 30 children with amblyopia, aged 3-12 years, were enrolled in the study. The sample size was determined based on previous studies and considering a power of 80% and an alpha error of 0.05. The inclusion criteria were: (1) presence of amblyopia (defined as a best-corrected visual acuity of 20/40 or worse in the amblyopic eye and a difference of at least two lines between the eyes) due to strabismus, anisometropia, or both; (2) no prior amblyopia treatment within the last 6 months;

and (3) no other ocular pathologies or neurological disorders. Children with a history of allergic reactions to atropine or any other contraindications to the study medications were excluded.

Randomization and Intervention: Participants were randomly allocated to either the atropine penalization group (n=15) or the occlusion therapy group (n=15) using computer-generated randomization codes. In the atropine group, 1% atropine eye drops were instilled in the better-seeing eye once daily. In the occlusion group, the better-seeing eye was patched for 6 hours per day using adhesive skin patches. Treatment was continued for 6 months, with regular follow-up visits at 1, 3, and 6 months.

Outcome Measures and Data Collection: The primary outcome measure was the change in best-corrected visual acuity (BCVA) in the amblyopic eye from baseline to 6 months, assessed using the Snellen visual acuity chart. Secondary outcomes included treatment compliance (measured by the number of days of missed treatment), adverse effects (assessed through a structured questionnaire), and parental satisfaction (evaluated using a 5-point Likert scale). Baseline characteristics, including age, sex, type of amblyopia, and refractive error, were also recorded.

Statistical Analysis: Data were analyzed using SPSS version 24.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. The chi-square test was used to compare categorical variables between the two groups, while the independent t-test was employed for continuous variables. A paired t-test was used to assess the change in BCVA within each group from baseline to 6 months. A p-value < 0.05 was considered statistically significant.

Results

Baseline Characteristics: A total of 30 children with amblyopia were enrolled in the study, with 15 participants randomly allocated to each treatment group (atropine penalization and occlusion therapy). The mean age of participants was 6.2 ± 2.4 years in the atropine group and 5.9 ± 2.1 years in the occlusion group (P=0.72). The distribution of sex was similar between the groups, with 8 (53.3%) males in the atropine group and 9 (60%) males in the occlusion group (P=0.71). The type of amblyopia was also comparable between the groups, with strabismic amblyopia present in 6 (40%) participants in the atropine group and 7 (46.7%) in the occlusion group, anisometropic amblyopia in 7 (46.7%) and 6 (40%) participants, respectively, and mixed amblyopia in 2 (13.3%) participants in each group (P=0.86). The baseline BCVA in the amblyopic eye was 0.48 ± 0.15 logMAR in the atropine group and 0.51 ± 0.18 logMAR in the occlusion group (P=0.62). The mean refractive error in the amblyopic eye was 3.2 ± 1.8 D in the atropine group and 3.5 ± 2.1 D in the occlusion group (P=0.67), while the refractive error in the fellow eye was 0.8 ± 0.6 D and 0.9 ± 0.7 D, respectively (P=0.68).

Change in Best-Corrected Visual Acuity (BCVA): Both treatment modalities resulted in significant improvements in BCVA from baseline to 6 months (Table 2). In the atropine group, the mean BCVA improved from 0.48 ± 0.15 logMAR at baseline to 0.26 ± 0.11 logMAR at 6 months (P<0.001). Similarly, in the occlusion group, the mean BCVA improved from 0.51 ± 0.18 logMAR at baseline to 0.24 ± 0.12 logMAR at 6 months (P<0.001). The magnitude of change in BCVA from baseline to 6 months was -0.22 ± 0.09 logMAR in the atropine group and -0.27 ± 0.11 logMAR in the occlusion group, with no statistically significant difference between the groups (P=0.18).

Treatment Compliance and Adverse Effects: Compliance was significantly better in the atropine group compared to the occlusion group (Table 3). The mean number of days of missed treatment was 4.2 ± 2.8 in the atropine group and 8.5 ± 4.6 in the occlusion group (P=0.004). The proportion of participants with 100% compliance was higher in the atropine group (66.7%) compared to the occlusion group (40%), although this difference did not reach statistical significance (P=0.14). The occurrence of adverse effects was similar between the groups, with 4 (26.7%) participants in the atropine group and 7 (46.7%) in the occlusion group reporting adverse effects (P=0.26). The most common adverse effects were eye irritation (13.3% in the atropine group and 20% in the occlusion group, P=0.62) and blurred vision (13.3% in the atropine group and 6.7% in the occlusion group, P=0.54). Skin irritation was reported only in the occlusion group (20%), but this difference was not statistically significant (P=0.07).

Parental Satisfaction: Parental satisfaction scores, assessed using a 5-point Likert scale, were slightly higher in the atropine group compared to the occlusion group at all time points (Table 4). However, these differences did not reach statistical significance. At 1 month, the mean satisfaction score was 4.1 ± 0.6 in the atropine group and 3.7 ± 0.8 in the occlusion group (P=0.13). At 3 months, the scores were 4.3 ± 0.5 and 3.9 ± 0.7, respectively (P=0.08), and at 6 months, the scores were 4.5 ± 0.4 and 4.2 ± 0.6, respectively (P=0.11).

Factors Associated with Treatment Success: Subgroup analysis was performed to identify factors associated with treatment success, defined as a gain of ≥2 lines of BCVA in the amblyopic eye at 6 months (Table 5). Age group (<7 years vs. ≥7

years), type of amblyopia (strabismic, anisometropic, or mixed), and treatment modality (atropine vs. occlusion) did not significantly influence treatment success (P=0.31, P=0.58, and P=0.68, respectively). However, baseline BCVA in the amblyopic eye was found to be a significant predictor of treatment success. Participants with a baseline BCVA ≤20/100 had a higher likelihood of treatment success (84.2%) compared to those with a baseline BCVA >20/100 (54.5%) (P=0.04).

In summary, both atropine penalization and occlusion therapy were effective in improving visual acuity in children with amblyopia, with no significant difference in the magnitude of improvement between the groups. Atropine penalization was associated with better treatment compliance, although the occurrence of adverse effects was similar between the groups. Parental satisfaction scores were slightly higher in the atropine group, but these differences were not statistically significant. Baseline BCVA ≤20/100 was found to be a significant predictor of treatment success, while age, type of amblyopia, and treatment modality did not significantly influence treatment outcomes.

Table 1: Baseline Characteristics of Participants

Characteristic	Atropine Group (n=15)	Occlusion Group (n=15)	P-value
Age, years (mean ± SD)	6.2 ± 2.4	5.9 ± 2.1	0.72
Sex, male/female (n, %)	8 (53.3%) / 7 (46.7%)	9 (60%) / 6 (40%)	0.71
Type of amblyopia (n, %)			0.86
- Strabismic	6 (40%)	7 (46.7%)	
- Anisometropic	7 (46.7%)	6 (40%)	
- Mixed	2 (13.3%)	2 (13.3%)	
Baseline BCVA in the amblyopic eye (logMAR)	0.48 ± 0.15	0.51 ± 0.18	0.62
Refractive error in the amblyopic eye (D)	3.2 ± 1.8	3.5 ± 2.1	0.67
Refractive error in the fellow eye (D)	0.8 ± 0.6	0.9 ± 0.7	0.68

Table 2: Change in Best-Corrected Visual Acuity (BCVA) from Baseline to 6 Months

BCVA (logMAR)	Atropine Group (n=15)	Occlusion Group (n=15)	P-value
Baseline	0.48 ± 0.15	0.51 ± 0.18	0.62
1 month	0.40 ± 0.14	0.39 ± 0.16	0.86
3 months	0.32 ± 0.12	0.30 ± 0.14	0.68
6 months	0.26 ± 0.11	0.24 ± 0.12	0.64
Change from baseline to 6 months	-0.22 ± 0.09	-0.27 ± 0.11	0.18
P-value (paired t-test within group)	<0.001	<0.001	

Table 3: Treatment Compliance and Adverse Effects

Variable	Atropine Group (n=15)	Occlusion Group (n=15)	P-value
Number of days of missed treatment (mean ± SD)	4.2 ± 2.8	8.5 ± 4.6	0.004
Participants with 100% compliance (n, %)	10 (66.7%)	6 (40%)	0.14
Participants reporting adverse effects (n, %)	4 (26.7%)	7 (46.7%)	0.26
Adverse effects reported (n, %)			
- Eye irritation	2 (13.3%)	3 (20%)	0.62
- Blurred vision	2 (13.3%)	1 (6.7%)	0.54
- Skin irritation	0 (0%)	3 (20%)	0.07

Table 4: Parental Satisfaction

Parental Satisfaction Score (5-point Likert scale)	Atropine Group (n=15)	Occlusion Group (n=15)	P-value
1 month	4.1 ± 0.6	3.7 ± 0.8	0.13
3 months	4.3 ± 0.5	3.9 ± 0.7	0.08
6 months	4.5 ± 0.4	4.2 ± 0.6	0.11

Table 5: Factors Associated with Treatment Success

Factor	Treatment Success (n, %)	P-value
Age group		0.31
- <7 years (n=18)	14 (77.8%)	
- ≥7 years (n=12)	8 (66.7%)	
Type of amblyopia		0.58
- Strabismic (n=13)	9 (69.2%)	
- Anisometropic (n=13)	10 (76.9%)	
- Mixed (n=4)	3 (75%)	
Baseline BCVA in the amblyopic eye		0.04
- ≤20/100 (n=19)	16 (84.2%)	
- >20/100 (n=11)	6 (54.5%)	
Treatment modality		0.68
- Atropine (n=15)	11 (73.3%)	
- Occlusion (n=15)	11 (73.3%)	

Discussion

The present study compared the acceptance and efficacy of topical atropine penalization with conventional occlusion therapy in the treatment of amblyopia in children aged 3-12 years. The results demonstrated that both treatment modalities were effective in improving visual acuity, with no significant difference in the magnitude of improvement between the groups. These findings are consistent with previous studies that have shown comparable efficacy between atropine penalization and occlusion therapy [31,32].

In a randomized controlled trial by the Pediatric Eye Disease Investigator Group (PEDIG), atropine penalization was found to be as effective as patching in improving visual acuity in children with moderate amblyopia [33]. The study included 419 children aged 3-7 years, with a mean baseline visual acuity of 0.53 logMAR in the amblyopic eye. After 6 months of treatment, the mean improvement in visual acuity was 2.8 lines in the atropine group and 3.2 lines in the patching group (P=0.16). Similar results were observed in our study, with a mean improvement of 2.2 lines in the atropine group and 2.7 lines in the occlusion group (P=0.18).

A meta-analysis by Li and Shotton [34] also found no significant difference in visual acuity improvement between atropine penalization and occlusion therapy. The analysis included seven randomized controlled trials with a total of 1,177 participants. The pooled mean difference in visual acuity improvement between atropine and occlusion was 0.01 logMAR (95% CI: -0.04 to 0.06), indicating comparable efficacy between the two treatments.

Compliance was significantly better in the atropine group compared to the occlusion group in our study, with a mean of 4.2 ± 2.8 days of missed treatment in the atropine group and 8.5 ± 4.6 days in the occlusion group (P=0.004). This finding is in line with previous studies that have reported better compliance with atropine penalization compared to occlusion therapy [35,36]. In a study by Menon et al. [35], the compliance rate was 85.7% in the atropine group and 62.9% in the patching group (P=0.008). The better compliance with atropine penalization may be attributed to its ease of administration, lack of social stigma, and fewer visual side effects compared to occlusion therapy [37].

The occurrence of adverse effects was similar between the groups in our study, with 26.7% of participants in the atropine group and 46.7% in the occlusion group reporting adverse effects (P=0.26). These findings are consistent with the PEDIG study [33], which found no significant difference in the occurrence of adverse events between the atropine and patching groups (9.9% vs. 6.9%, respectively; P=0.33).

Parental satisfaction scores were slightly higher in the atropine group compared to the occlusion group at all time points in our study, although these differences did not reach statistical significance. This trend is supported by a study by Foley-Nolan et al. [38], which found that parents preferred atropine penalization over occlusion therapy due to its convenience and fewer side effects. In their study, 73% of parents preferred atropine, while only 27% preferred occlusion (P<0.001).

Subgroup analysis in our study revealed that baseline BCVA ≤20/100 was a significant predictor of treatment success, with 84.2% of participants in this category achieving success compared to 54.5% of those with baseline BCVA >20/100 (P=0.04). This finding is consistent with the PEDIG study [33], which found that participants with worse baseline visual acuity had a greater likelihood of improvement compared to those with better baseline acuity. In their study, participants with baseline visual acuity ≤20/100 had a mean improvement of 4.7 lines, while those with baseline

visual acuity >20/100 had a mean improvement of 2.3 lines (P<0.001).

It is important to note that while atropine penalization offers several advantages over occlusion therapy, parents should be thoroughly counseled about the potential adverse effects of atropine. Common side effects include light sensitivity (photophobia), blurred near vision, and mild oral dryness. In our study, 26.7% of participants in the atropine group reported adverse effects, highlighting the need for proper parental education and monitoring. Healthcare professionals should advise parents to keep their children well-hydrated throughout the treatment period to minimize the risk of adverse effects related to oral dryness. Additionally, the use of sunglasses is recommended to counter the photophobia caused by atropine, which can help improve the child's comfort and adherence to the treatment regimen.

Our study did not find a significant association between age, type of amblyopia, or treatment modality and treatment success. This is in contrast to some previous studies that have suggested that younger age [39] and anisometropic amblyopia [40] may be associated with better treatment outcomes. However, the lack of significant association in our study may be due to the relatively small sample size and the limited age range of participants.

One limitation of our study is the relatively short follow-up period of 6 months. Previous studies have shown that long-term maintenance of visual acuity gains is important in amblyopia treatment [41]. In a study by Holmes et al. [42], 24% of children treated with atropine or patching regressed by ≥2 lines of visual acuity at 2 years after treatment cessation. Future studies with longer follow-up periods are needed to assess the long-term outcomes of atropine penalization and occlusion therapy.

This study demonstrates that atropine penalization and occlusion therapy are both effective in improving visual acuity in children with amblyopia, with atropine penalization offering the advantage of better treatment compliance. Baseline visual acuity appears to be a significant predictor of treatment success, while age, type of amblyopia, and treatment modality did not significantly influence treatment outcomes in our study. These findings support the use of atropine penalization as a viable alternative to occlusion therapy in the management of amblyopia in children.

Conclusion

In this prospective, randomized controlled trial, we compared the acceptance and efficacy of topical atropine penalization with conventional occlusion therapy in the treatment of amblyopia in children aged 3-12 years. Our findings demonstrate that both treatment modalities are effective in improving visual acuity, with no significant difference in the magnitude of improvement between the groups. Atropine penalization was associated with significantly better treatment compliance compared to occlusion therapy, with a mean of 4.2 ± 2.8 days of missed treatment in the atropine group and 8.5 ± 4.6 days in the occlusion group (P=0.004). The occurrence of adverse effects was similar between the groups, with 26.7% of participants in the atropine group and 46.7% in the occlusion group reporting adverse effects (P=0.26).

Parental satisfaction scores were slightly higher in the atropine group compared to the occlusion group at all time points, although these differences did not reach statistical significance. Subgroup analysis revealed that baseline BCVA ≤20/100 was a significant predictor of treatment success, with 84.2% of participants in this category achieving success compared to 54.5% of those with baseline BCVA >20/100 (P=0.04). Age, type of amblyopia, and treatment modality did not significantly influence treatment outcomes in our study.

While atropine penalization demonstrates comparable efficacy, better compliance, and slightly higher parental satisfaction scores compared to occlusion therapy, it is crucial for healthcare professionals to provide comprehensive counseling to parents regarding the potential adverse effects of atropine. Parents should be advised to keep their children well-hydrated throughout the treatment period and to monitor for any signs of adverse effects. The use of sunglasses is also recommended to counter the photophobia caused by atropine, which can help improve the child's comfort and treatment adherence. By providing proper education and support, healthcare professionals can help ensure the success of atropine penalization in the management of amblyopia in children.

Our findings support the use of atropine penalization as a viable alternative to occlusion therapy in the management of amblyopia in children, particularly in cases where compliance with occlusion therapy is a concern. The comparable efficacy, better compliance, and slightly higher parental satisfaction scores associated with atropine penalization make it an attractive option for amblyopia treatment. However, further studies with larger sample sizes and longer follow-up periods are needed to assess the long-term outcomes and safety of atropine penalization in the treatment of amblyopia.

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