Prisms in the treatment of diplopia with strabismus of various etiologies

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Purpose: We aimed to study the success of prism in regard to diplopia resolution score and associated factors in patients presenting with symptomatic diplopia arising from various etiologies. Methods: In this descriptive, retrospective study diplopia resolution among 31 patients who were prescribed prism were analyzed. Results: Fifty-four patients were evaluated for diplopia and 31 were included for the study done over 3 years. The mean follow-up was 15 months. Esotropia, exotropia, and hypertropia were seen in 39%, 51%, and 19.4% of patients, respectively. Furthermore, 71% received Fresnel prism and 29% were given ground glass prism. The mean prism power prescribed was 13.3 PD. 87% had complete resolution of diplopia; 96.8% continued usage of prism. High success rates were seen among patients with decompensated strabismus, sixth and fourth nerve palsy. Horizontal prism and oblique prism in the form of Fresnel prism yielded complete resolution of diplopia ($P = 0.028$). There was no association between the success of prism and etiology ($P = 0.058$), history of trauma ($P = 0.212$), and type of deviation ($P = 0.387$). The study showed that oblique Fresnel prism can be considered for combined deviation. Conclusion: Our study showed prism to be effective in alleviating diplopia over a varied range of etiologies.

Key words: Cranial nerve palsy, diplopia, prisms, strabismus

Prism is a transparent, solid, triangular refracting medium with a base and an apex. Prisms are prescribed for optical correction of symptomatic binocular diplopia due to strabismus-based visual disorders. It becomes the only way of salvation in many ophthalmic clinical situations. They alleviate diplopia by altering the path of light rays and aligning the image on the fovea of the deviating eye. Published reports on the success of prisms in treating diplopia are limited to a few case series and lack a detailed description of ocular misalignment, type and amount of prism prescribed, and follow-up data on the efficacy of treatment. It is believed that prisms are ineffective in larger and oblique (horizontal and vertical) deviations, although no large studies exist to support this belief.

In our study, we described the effectiveness of prism in 31 patients with symptomatic diplopia in terms of diplopia resolution score and factors associated with it for different etiologies and ocular misalignments.

Methods

Our study is a descriptive, retrospective cohort study done by reviewing medical records between 2017 and 2019 of patients who presented to our strabismus clinic with symptomatic diplopia from various etiologies.

Inclusion criteria

Patients who were prescribed prisms for fourth nerve palsy, sixth nerve palsy, third nerve palsy, decompensated strabismus, thyroid-related orbitopathy, and other restrictive strabismus, and those who had a minimum follow-up of 2 months post prism prescription.

Exclusion criteria

The study excluded patients due to insufficient follow-up and those who declined prisms secondary to dissatisfaction.

In this analysis, 54 consecutive patients were prescribed prisms for the management of diplopia arising due to different etiologies and over a broad range of ocular misalignment. Thirty-one patients were included in the study.

In the study, analysis of the demographic features of the patients, such as age, sex, features of diplopia such as duration of diplopia, measurement of deviation in all gazes, systemic risk factors, amount and type of prism dispensed, compliance of prism usage, success of prism in follow-up, and the need for strabismus surgery in cases of failure were noted.

Prisms were prescribed to patients after a meticulous prism trial. One-third of the total measured deviation in primary position was put in front of the affected eye after giving appropriate refractive correction. The patient was asked to...
read the 20/400 (6/60) line, and prismatic power was slowly increased/decreased till the patient reported freedom from diplopia. Distance, near, and down gaze positions were tested. Prisms up to 10 PD are well tolerated when ground into lenses. In the present study, till 6 PD, prisms were given as ground in glasses. If the prisms exceeded 6 PD, then they were split in front of both eyes or Fresnel prisms were tried in front of the affected eye. Patients were informed about the advantages and possible disadvantages such as reduction in visual acuity, reduction in contrast, optical aberrations, and scattering of light. The possibility of spontaneous recovery over a course of time was explained to all patients. For oblique prism, an oblique axis was based on the appropriate vector addition calculated by adding vectors and approximating angles guided by the previously reported table of Reinecke et al.[9]

The resolution or improvement in diplopia was ascertained from follow-up records at least once at 2 months post prism prescription. A diplopia resolution score was assigned based on the patient’s self-report (1 = complete resolution of diplopia; 2 = partial resolution with residual diplopia; 3 = ineffective for diplopia management). “Successful prism use” included those patients who were assigned a score of 1 or 2.

Statistical analysis
Data were analyzed using statistical software STATA 14.0, StataCorp, Texas, USA. Continuous data such as age and duration were presented with mean, standard deviation, and minimum and maximum values. Categorical data such as squint type, history of trauma, and prescribed prism were presented as count with percentage. To find the association between categorical variables, a Fisher’s exact test was used and \( P < 0.05 \) was considered statistically significant (95% C.I) for all variables.

Results
Of the 54 patients evaluated for symptomatic diplopia, 31 patients were taken into the study after meeting the inclusion criteria. They had a mean follow-up of 15 ± 10.6 months (range: 2–48 months). The mean age of the cohort was 37 ± 16.8 years (range: 18–78 years). The mean duration of diplopia among the study group was 11 ± 10.5 months (range: 1–36 months). Among them, 24 were males and 7 were females. Seventy-one percent had no systemic illness. Twenty-nine percent of the study group had associated systemic illness, including diabetes mellitus in 3 patients, dyslipidemia and hypertension in 2 patients, and thyroid dysfunction in 4 patients. Patients with a history of trauma associated with the onset of diplopia was found among 22.6% (\( n = 7 \)).

Table 1 describes the etiology of the study group in which 22.6% of patients developed diplopia due to decompensated strabismus. In our cohort, 25.8% (\( n = 8 \)) of patients presented with diplopia following ocular procedures. These include 3 patients post orbital procedures, 3 patients post retinal detachment surgery, and 2 patients following cataract surgery. Both these patients had undergone phacoemulsification under topical anesthesia. Diplopia was reported at 1-month postoperative period. Both patients had exotropia, prescribed Fresnel prism, and had success with prism during the follow-up period. 12.9% presented due to thyroid-related orbitopathy. Diplopia presenting due to cranial nerve palsies such as fourth nerve palsy, third nerve palsy, and sixth nerve palsy was seen among 12.95%, 6.4% and 19.4%, respectively.

Esotropia, exotropia, and hypertropia were seen in 39%, 51%, and 19.4%, respectively. Mean horizontal deviation for near and distance in the study group were 12.4 PD and 11.8 PD, respectively. Mean vertical deviation for near and distance in the study group were 6.5 PD and 7.3 PD, respectively. Ten patients (32.3%) had prior squint surgery before initiating prism. Of them, 7 patients had undergone both horizontal recti muscle surgery and 3 had undergone single vertical recti muscle surgery for vertical deviation, and prisms were prescribed for the residual deviations.

Mean prism power prescribed was 13.3 PD (range: 4–25 PD). Twenty-nine percent received ground glass prism and 71% received Fresnel prism. The range of Fresnel prism power prescribed was 12–25 PD. In the study group, horizontal and vertical prism were prescribed among 51.6% and 25.8%, respectively. Further, 12.9% received combined prism (split as horizontal prism in one eye and vertical prism in the other eye in the form of ground glass prism for combined deviations). Oblique prism based on the Reinecke table was prescribed among 9.7% of patients.

96.8% continued usage of prism; 87.1% had complete or partial resolution of diplopia, indicating the success of prism. Higher success rates were seen for decompensated strabismus and sixth and fourth nerve palsy (100%). Fig. 1 bar graph depicts the factors associated with success of prism. Patients given horizontal and oblique prism in the form of Fresnel prism showed complete resolution of diplopia with a statistical significance (\( P = 0.028 \)). There was no association between the success of prism and etiology (\( P = 0.058 \)), history of trauma (\( P = 0.212 \)), and type of deviation (\( P = 0.387 \)).

Four patients (12.9%) were unhappy with the prism. Of them, two had a history of trauma. One of them developed traumatic third cranial nerve palsy and the other had traumatic retinal detachment for which he underwent scleral buckle surgery following which he developed diplopia and prescribed prism. The other two patients who were unhappy with the prism had diplopia due to thyroid orbitopathy. Of these four patients who were unhappy with prisms for diplopia, three of them had undergone strabismus surgery prior to initiation of prism for resolving the diplopia.

One patient (3.2%) opted for strabismus surgery following partial resolution of diplopia. This patient was a 20-year-old male who presented with exotropia and diplopia following corneal tear repair done a year ago. He was not comfortable with prism due to partial resolution of diplopia and had

| Etiology                        | n   | %    |
|---------------------------------|-----|------|
| Decompensated strabismus        | 7   | 22.6 |
| Thyroid-related orbitopathy     | 4   | 12.9 |
| Fourth nerve palsy              | 4   | 12.9 |
| Third nerve palsy               | 2   | 6.4  |
| Sixth nerve palsy               | 6   | 19.4 |
| Post ocular surgeries           | 8   | 25.8 |
| Total                           | 31  | 100  |
discontinued the Fresnel prism. This patient had undergone lateral rectus muscle recession and his diplopia was resolved.

**Discussion**

Prism is a powerful tool that can be used to successfully treat a variety of ocular conditions resulting in diplopia. Prisms can be dispensed as “ground in” prisms or “stuck on” Fresnel prisms. In this retrospective study of patients with symptomatic diplopia from various etiologies, we found prisms to be an effective tool in relieving binocular diplopia. Eighty-seven percent of patients reported satisfaction with prism. Previously in a comparable study by Tamhankar et al., among 94 patients, 88% reported complete or partial resolution of double vision, with the highest improvement noted in the divergence insufficiency and skew deviation group (100%) compared to 64% improvement noted in patients with convergence insufficiency. In the same study, 85% of patients who were prescribed prism greater than 10 PD and those with oblique prism prescriptions also reported resolution of diplopia. Eighty-nine percent of the cohort continued with prism use, while 15% opted for strabismus surgery. In our study, 11.9% were unhappy with prism and were presenting with traumatic third cranial nerve palsy, traumatic retinal detachment, and thyroid-related orbitopathy.

Fourth cranial nerve palsy is the most common cause for an isolated vertical deviation. It can cause intolerable diplopia, which may be vertical, diagonal, or torsional. Tamhankar et al. and Neena et al. reported 92% and 76% of the patients, respectively, who had acquired unilateral superior oblique palsy and were satisfied with the use of prisms. In the latter stated series, 52% had spontaneous recovery. In our series, all four patients with fourth nerve palsy were satisfied with prism usage.

In paralytic strabismus, prisms are used to relieve diplopia by directing the extra image into the suppression area or into the retinal periphery, where it can be easily ignored. Prisms are used to stimulate the unaffected antagonistic muscle of the paretic muscle, thereby preventing its secondary contracture. Fresnel prisms are now used more in prism practice as they are very thin, have only negligible weight, and are more cosmetically acceptable even in high powers (30 PD) than conventional prisms. They are made of polyvinyl chloride. Fresnel prisms consist of thin narrow prisms arranged in a plastic sheet. As Fresnel prism is thin and flexible, it can be cut into pieces and applied to the back surface of spectacle. They are preferred in most of the clinical conditions managed with prisms, especially in the treatment of squint and to relieve sudden-onset symptomatic diplopia resulting from fourth and sixth cranial nerve palsies, thyroid-related orbitopathy, post cataract surgery diplopia, and trauma-induced diplopia.

Diplopia is a potential undesirable outcome of nearly any ocular surgery. In our study group, 25.8% of patients presented following ocular procedures. Diplopia has been documented as a result of restrictive strabismus following vitreoretinal surgery, glaucoma surgery, orbital decompression surgery, strabismus surgery, orbital surgery, conjunctival surgery, cataract surgery,
and blepharoplasty. The use of retrobulbar or peribulbar injections may cause injury to the extraocular muscle fibers directly or anesthetic infiltration (local myotoxicity). This may lead to muscle fiber destruction and create permanent fibrosis, compromising the function. This has been implicated as a cause of strabismus after cataract and retinal detachment surgery. The patient with diplopia following retinal surgery presents a challenge. Hodgetts reported that diplopia persisting beyond 6 months is noted in 5%–25% of cases. Mechanical and sensory factors may combine to preclude single binocular vision, and neutralizing the patient’s strabismus may not be sufficient to permit resolution of their diplopia. The treatment of diplopia after ocular surgery is complicated by the incomitance and torsion associated with restrictive strabismus as well as the variability of the deviation during healing. Nonsurgical options such as prisms have to be considered in these cases.

In the study period, though 54 patients were evaluated and prescribed prism, only 31 patients (57.4%) had received prism, which denotes a challenge of prism acceptance among our patients. Also, patients with prior squint surgery who received prism for resolution of residual diplopia were found unhappy among our study cohort. The mean age of the present study group was 37 years (range: 18–78 years) compared to 68.9 years in a study by Tamhankar et al. In clinical practice, the prism acceptance is more among younger individuals and reluctance is commonly expressed among older patients. All patients need to be encouraged and provided an option of prims for resolving diplopia. Though difficult, oblique Fresnel prism should be prescribed for combined deviations, which will increase the success. Gunton BK et al. states that satisfaction with prismatic correction is achieved in approximately 80% of all adult patients with diplopia. Of patients with vertical diplopia, skew deviation and fourth nerve palsy have the highest satisfaction rates (100 and 92%, respectively). Our results indicate that prisms can be considered as initial management in patients with a wide range and variety of etiologies of ocular deviations, including larger and mixed strabismus, and do not have to be limited to smaller deviations.

The decision to prescribe prisms should not be based simply on the amount of misalignment but on other factors such as etiology, type of deviation, and degree of fusional amplitude. Most patients will require a prism power of 65% or more of their deviation, although the amount of prism required varies based on the age, fusional amplitudes, and type of deviation of the patient. Fresnel prisms can be tried initially and can be considered as an alternative for diplopia in these patients. Careful selection of patients for prismatic correction, management of patients’ expectations, and continued follow-up to monitor the symptoms are critical to the successful use of prisms. Prism prescriptions often greatly improve the quality of life of patients by reducing asthenopia and diplopia. Although prescribing it can seem intimidating at first, with practice and a bit of trial and error, one can perfectly prescribe prism with ease.

Limitations of our study include small sample size, retrospective nature of the study, and short duration of follow-up.

Conclusion
Finding a treatment plan that helps to alleviate the disturbing diplopia and considering the patient’s preferences is a challenge but can be accomplished through the use of prisms. Our study showed Fresnel prisms to be effective in alleviating diplopia over a varied range of etiologies. We recommend that prisms be offered as a primary treatment for all patients with symptomatic diplopia.

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Conflicts of interest
There are no conflicts of interest.

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