CURRENT OPINION

Prism use in adult diplopia

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Purpose of review
Prismatic correction to restore binocularity in adult diplopia can be challenging. This review summarizes the results of prismatic correction in adults based on the cause of diplopia.

Recent findings
Satisfaction with prismatic correction is achieved in approximately 80% of all adult patients with diplopia when combining the causes. Of patients with vertical diplopia, skew deviation and fourth nerve palsy have the highest satisfaction rates, 100 and 92%, respectively. Patients with thyroid eye disease and orbital blowout fractures associated with diplopia had the lowest satisfaction rates, 55 and 8%, respectively. With regard to horizontal deviations, patients with decompensated childhood strabismus with a combination of horizontal and vertical deviations and patients with convergence insufficiency had the lowest satisfaction rates, 71 and 50%, respectively.

Summary
Careful selection of patients for prismatic correction, management of patient's expectations, and continued follow-up to monitor the symptoms are critical to the successful use of prisms.

Keywords
adult, diplopia, Fresnel, prism

INTRODUCTION

Adults with symptomatic diplopia often have severe functional disability. Patients with adult-onset strabismus lack the ability to create suppression scotomas to adapt to their deviation, thereby creating constant diplopia. The deviations may be incomitant with diplopia only in certain gazes. The deviations may be large and exceed normal fusional vergences. Restoring functional binocularity is critical for these patients. Binocularity may be achieved with a variety of treatment options including traditional ground-in prisms, Fresnel prisms, eye muscle surgery, occlusion, or a combination of these options. Resolution of diplopia in the primary position is usually considered the successful treatment. Secondarily, diplopia in downgaze needs to be addressed to restore functionality for reading. Patient expectations of treatment need to be addressed early in diplopia management.

The most appropriate treatment for a patient is selected with consideration of various factors including the cause of the diplopia, severity of symptoms, overall patient health, and cost considerations. Prisms correct strabismus by altering the pathway of light, moving images onto the fovea of the deviated eye or within a range to allow fusion of the images if possible. Prisms can be ground into spectacle lenses or a Fresnel prism can be applied. In general, prisms are considered effective for small, comitant deviations. Data is emerging for their use in larger and incomitant deviations as well. Prisms have also been used for the relief of symptoms in decompensated phorias and long-standing strabismus of childhood.

This article reviews the results of prism use in adult diplopia secondary to common causes. This includes vertical deviations secondary to fourth nerve palsy, thyroid eye disease, skew deviation, and blowout fracture as well as horizontal deviations secondary to sixth nerve palsy, decompensated phoria, divergence insufficiency, and convergence insufficiency.

FRESNEL PRISMS

The Fresnel principle states that prismatic or refractive power can be achieved by employing a

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KEY POINTS

- In vertical diplopia, successful correction with prism requires approximately 90% of the deviation in primary position to be prescribed.
- Realistic patient expectations, frequent follow-up, and patient's age greater than 65 are more likely to result in successful use of prism.
- Patients with convergence insufficiency and incomitant deviations such as thyroid eye disease and orbital blowout fracture associated diplopia are least likely to have resolution of their diplopia with prisms.

concentric set of prismatic rings with the face of each ring having the prismatic power or curvature of the lens element it replaces, respectively. Fresnel prisms are 1.0 mm in thickness regardless of the power of their prismatic correction. The thinner prism allows a wider range of prismatic corrections to be used in spectacles. Once the Fresnel prism was modified with optical-grade polyvinyl chloride, allowing the application of the prism directly to spectacle lenses, their use became more widespread [1]. In most cases, the cost of Fresnel prisms is much lower than ground-in prisms. Fresnel prisms are particularly effective in temporary situations, such as sixth and fourth nerve palsies from microvascular insults when resolution of the diplopia is expected. They are also useful when deviations vary between near and distance. Fresnel prisms can be applied to only the top or bottom of a spectacle lens, allowing for positional variability in the deviation to be addressed. When the exact prismatic correction needed is unknown, the cost advantage also favors Fresnel prisms. Fresnel prism can be used in cases of larger deviations, as an initial trial prior to permanent prism spectacles, large lateral incomitance, and when uncertainty exists in a patient's subjective response to prism [2▪].

Fresnel prisms have some disadvantages. The degradation of visual acuity in the distance is more with Fresnel lenses of greater than 12 prism diopters compared with traditional ground-in prisms [3]. There are also increased optical aberrations, loss of contrast and light scatter in larger Fresnel prisms. In addition, the grooves of the Fresnel are cosmetically visible. Further optical degradation occurs when dust and other small particles accumulate within the grooves of the Fresnel prism. Inadequate application of the Fresnel prism allows trapped air pockets between the Fresnel membrane and the spectacle lens, further degrading visual acuity. Twenty percentage of patients in one study discontinued Fresnel prism usage because of these side effects [1]. In another study, only 8% continued in Fresnel prism once satisfactory treatment of the diplopia was achieved [2▪]. The balance of these disadvantages against the advantages has led to the frequent use of Fresnel prisms to correct diplopia.

Because of the limitations, the Fresnel should only be applied to one eye. Typically, the nondominant eye is chosen for the application of the Fresnel because of the effect on visual acuity. Horizontal and vertical prism can be achieved through the oblique application of an appropriate prism onto the spectacles [4]. In cases of reduced visual acuity in one eye, for example, from macular disease or optic neuropathy, the Fresnel can be effectively used to eliminate diplopia [5]. The resulting further reduction in visual acuity is well tolerated.

VERTICAL DEVIATIONS

There are many causes for vertical diplopia. Prism use in fourth nerve palsy, skew deviations, decompensated childhood strabismus, thyroid eye disease, and blowout fractions will be covered in this section.

Fourth nerve palsies

Vertical deviations are often more disabling in adults because of low vertical fusional amplitudes. Although the typical prism prescribed for horizontal deviations is generally 50% of the total deviation, a greater percentage of the total deviation is needed for vertical strabismus. Incomitance in fourth nerve palsies is particularly difficult to address with prisms. In fact, some studies have suggested that prism should not be attempted in patients with fourth nerve palsy because of the incomitance [6]. A recent review of fourth nerve palsies showed good outcomes with prism [7▪]. In this study, adults with acquired fourth nerve palsy had an average vertical deviation in primary position of 5.5 prism diopters. Most patients did not have an accompanying horizontal deviation. These patients required the full 5.5 prism diopters of correction to relieve the diplopia, consistent with poor vertical fusional amplitudes. In the same review, patients with symptomatic congenital fourth nerve palsies had larger deviations in primary with a mean deviation of 8.3 prism diopters. These patients required a mean prismatic correction of 6 prism diopters or 73% of their total deviation. In another review of patients with both congenital and acquired fourth nerve palsies, the mean deviation in primary was 7.7 prism diopters and a mean correction of 6 prism diopters in Fresnel prism was prescribed [1].

Successful use of prism was subjectively reported by Tamhankar *et al.* [7▪] as completely satisfied, mostly satisfied (with some residual diplopia or asthenopia), or unsatisfactory because of persistent diplopia. In this retrospective review, all patients included in the study were treated with prism, probably resulting in a physician bias of patient selection [7■]. Prism would only be prescribed if the physician felt the patient was likely to be satisfied. Nevertheless, with these criteria for success, 75% of patients with congenital fourth nerve palsy were completely satisfied and 92% were completely or mostly satisfied. In patients with acquired fourth nerve palsy, 78% were completely satisfied with prism correction and 86% were completely or mostly satisfied [7■]. In the Fresnel study, 50% of patients continued with Fresnel prism correction permanently [1]. High success rates may result from adequate management of patient expectations. In addition, patients with congenital fourth nerve palsies have high vertical fusional amplitudes, allowing for better fusion in gazes in which the deviation is not fully corrected with prisms.

Skew and decompensated childhood strabismus

A similar study of patients with skew deviation found that prism correction for on average 92% of the total vertical deviation in primary position resulted in 100% satisfaction with prism treatment in a small group of patients [2■]. The mean vertical deviation in primary position was small (5.5 prism diopters), and the total mean correction was essentially the total deviation (6.1 prism diopters). In patients with decompensated strabismus, the mean vertical deviation was even smaller (4.0 prism diopters) with full prismatic correction given [2■]. Patients with decompensated strabismus also had horizontal deviations, and oblique prism was attempted. Possibly because of the combination of vertical and horizontal prism, these patients reported a lower prism satisfaction rate of 85%. In another study of patients with vertical diplopia from long-term disruption of fusion, most patients had a combination of horizontal and vertical deviations [8]. Horizontal deviations were managed with exercises to increase horizontal fusional vergences. Vertical deviations were treated with prism. Successful resolution of diplopia was reported in three of the five patients in this report.

Thyroid eye disease

Patients with thyroid eye disease-related strabismus also often have incomitant deviations because of greater disease involvement of the inferior and medial rectus muscles. The average prismatic correction for thyroid eye disease patients was 9.2 prism diopters, with 72% of cases needing vertical prism [1]. Fresnel prism adequately corrected the diplopia in primary position for all but one patient, although the satisfaction with prism was reduced in this incomitant condition with only 55% of patients reporting complete satisfaction.

Patients with thyroid eye disease following inferior rectus recession may also present with diplopia limited to downgaze. Options to correct this situation include Fresnel prism in the bifocal segment, separate reading glasses with prism, ground-in prism in the bifocal segment by slab-off, unequal bifocal heights with induced prism, or occlusion of the bifocal segment for the non-dominant eye. Fresnel prism in the bifocal segment is often not tolerated in these patients because of image blur [9]. In Kushner's [9] study, only 11% of patients were satisfied with this treatment. Ground-in prism in the bifocal segment using slab-off or reverse slab-off technique was also poorly tolerated because of the increasing deviation in progressive downgaze (17% success) [9]. The most successful treatment for this condition was raising the bifocal segment in the spectacles and switching progressive-type bifocals for classical bifocal segments [9].

Blowout fractures

Patients with diplopia associated with blowout fractures have the additional treatment option of orbital fracture repair. Diplopia may occur from entrapment of the muscle, muscle or soft-tissue edema, muscle fibrosis, or associated cranial nerve palsies. In cases of entrapment of the inferior or medial rectus muscle, release of the muscle and fracture repair should be instituted usually within 48 h of the injury. The reported incidence of diplopia following blowout fractures varies from 57 to 86% [10,11]. In a review of diplopic cases, 63–74% of patients had elimination of the diplopia with orbital fracture repair [10,12]. In another study, diplopia was eliminated in 89% of patients with orbital fracture repair alone [13]. Alternatively, strabismus surgery can be delayed from the time of injury by several months to allow improvements in periorbital tissue and extraocular muscle edema and hemorrhage. The mean time to strabismus surgery following trauma was 10 months in Ceylan *et al.*'s [12] cohort. Eighteen percentage of all the patients required strabismus surgery. Persistent diplopia remained in 2% of patients in a large cohort with blowout fractures following orbital repair from Spain [14■]. Eight percent of Ceylan's patients were successfully treated with prism without strabismus surgery [12].

In patients undergoing inferior rectus recessions for diplopia from orbital floor fracture, postoperative persistent diplopia in downgaze may occur if the involved inferior rectus muscle is partially paralyzed or suffers a flap tear from the orbital fracture. This results in a hypertropia of the involved eye in downgaze. The treatment options then become the same as for thyroid patients with the similar complaint of diplopia in downgaze only.

HORIZONTAL DEVIATIONS

There are a vast number of causes for horizontal diplopia. The results of prism in sixth nerve palsy, divergence insufficiency, decompensated childhood strabismus, and convergence insufficiency are reviewed in this section.

Sixth nerve palsies

In patients with horizontal deviations, such as sixth nerve palsies, fusional divergence can be utilized to allow for smaller prismatic correction to re-establish binocularity, but the lateral incomitance can be disabling. In one study, the average deviation in a group of patients with sixth nerve palsy was 13 prism diopters at distance [1]. The average prismatic correction was 9 prism diopters. The success rate with prismatic treatment in patients was not reported for this cohort specifically, but on average was 80% of all patients with diplopia from several causes in the study [1]. Four of 22 patients (18%) with partial recovery of their sixth nerve palsy had elimination of their diplopia with prisms in one study [15].

Divergence insufficiency

Another group of patients with horizontal deviations are patients with divergence insufficiency. This group has an esotropia greater in the distance than at near. The mean deviation was 9.8 prism diopters for this group in one study [2▪]. The average prismatic correction was 7.7 prism diopters. The success rate of prism was 100% in the 30 patients reported in the study. Other studies have suggested vergence exercises [16] or eye muscle surgery [17] to treat these patients.

Decompensated childhood strabismus

Patients with diplopia from decompensated childhood strabismus may also be managed with prisms [18]. Seventy-four percent of adult patients with strabismus have horizontal deviations, seventeen have vertical deviations, and combined horizontal and vertical deviations occur in 9% [18]. The mean horizontal deviation in a group of adults with decompensated strabismus was 18 prism diopters of exotropia and 15 prism diopters of esotropia [2▪]. The mean correction prescribed in prism was 11 prism diopters and 8 prism diopters, respectively. Prism successfully resolved diplopia in the primary position in 71% of this group of patients with decompensated esotropia and exotropia combined [2▪]. All but one of the patients in this group had greater than 10 prism diopters prescribed. The satisfaction rate did not differ significantly between patients who had esotropia compared to exotropia. Patients requiring both horizontal and vertical prism (i.e. oblique prism) had the least satisfaction, 57% [2▪].

Convergence insufficiency

Prism correction for convergence insufficiency presents several unique problems. In convergence insufficiency, diplopia occurs because of an exodeviation at near greater than in the distance or with no distance deviation. In Tamhankar *et al.*'s [2▪] study, the mean deviation for patients with convergence insufficiency was 12 prism diopters, with 8 prism diopters prescribed in prismatic correction. Only 50% of patients had complete resolution of diplopia with prismatic correction. The authors speculated that need for prism only at near makes the prism harder to use for these patients. In children, base-in prism also did not prove successful in the treatment of convergence insufficiency [19]. Convergence exercises have been successful in the treatment of convergence insufficiency [20]. One study randomized presbyopic patients with convergence insufficiency to glasses with base-in prism correction or presbyopic correction alone. This study revealed a greater improvement in convergence insufficiency survey scores in patients with prism [21].

CONCLUSION

Patients have good success with long-term use of prisms. In one study, through the follow-up period of 2 months to 6 years, 86% of the patients continued with prism use, whereas 14% of patients opted for surgical intervention [2▪]. Although the patients with larger deviations in primary position were less satisfied, surprisingly, 80% still had mostly satisfactory use of the prism. Patients older than 65 years were more likely to be satisfied with prism in this study. Sex, strength of prism, duration of diplopia, or follow-up was not statistically associated with successful use of prism [2■].

Successful use of prism requires correction of the entire deviation in cases of vertical deviations such as acquired fourth nerve palsy in order to achieve satisfaction for patients. Prism is least likely to successfully control symptoms in convergence insufficiency. Realistic patient expectations of prism usage, frequent follow-up of patients to ensure control of symptoms, and modification of prism improve patient satisfaction.

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Conflicts of interest

There is no conflict of interest by either author.

REFERENCES AND RECOMMENDED READING

Papers of particular interest, published within the annual period of review, have been highlighted as:
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Additional references related to this topic can also be found in the Current World Literature section in this issue (pp. 000–000).

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