

Use of Bangerter filters with adults having intractable diplopia

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KEYWORDS

Bangerter filters;
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Abstract

PURPOSE: The aim of this study was to describe the use of Bangerter filters in adults having intractable diplopia.

METHODS/CASE REPORTS: A series of adults having intractable diplopia caused by either cyclotorsion, retinal disease, monocular diplopia, or rapid alternating fixation who were treated with Bangerter filters is reported. Detailed case reports on 4 of the 10 patients are included.

CONCLUSION: Bangerter filters can be used to mitigate diplopia that cannot be eliminated with either prism, modification of the spectacle prescription, vision therapy, or extraocular muscle surgery. The weakest density filter that eliminates the diplopia should be prescribed. Prospective studies reporting the long-term efficacy and quality of life with the filters are needed.

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Bangerter occlusion filters or foils (Reyser Optik AG, St. Gallen, Switzerland) are graded, partially occlusive filters that have been used mostly in Europe since 1960 to treat amblyopia.¹⁻³ These thin translucent plastic filters are designed to induce progressive degradation in visual acuity. They are placed on the inner surface of a patient's non-amblyopic eye spectacle lens much like a thin membrane plastic Fresnel prism. Bangerter filters vary in strength from the most dense, which produce severe reduction in visual acuity, to the barely occlusive, in which nearly normal visual acuity is possible (*see Table 1*). However, each filter density can induce a variable range of visual acuity degradation and does not necessarily correspond to the manufacturer's predicted levels.^{4,5} Unlike full opaque occlusion, low- to moderate-density Bangerter filters degrade visual acuity while allowing peripheral fusion, a full visual field, and favorable cosmesis.

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Bangerter filters have also been used in adults who have intractable diplopia.^{6,7} In these cases, the filter is placed before the spectacle lens of the affected eye (*see Figure 1*). Bangerter filters have been prescribed to alleviate diplopia not amenable to either prism therapy, modification of spectacle lens parameters, orthoptics/vision therapy, or strabismus surgery. This report describes the use of Bangerter filters in 4 adults having diplopia caused by either cyclotorsion, retinal disease, monocular diplopia, or rapid alternating fixation. These patients were selected because they typify the complicated binocular vision problems of these conditions. The additional patients treated with Bangerter filters are summarized in *Table 2*. This study was approved by the Institutional Review Board for Human Use at the University of Alabama at Birmingham.

Diplopia caused by cyclotorsion

Acquired cyclovertical strabismus that is either paretic or mechanically restrictive will result in horizontal, vertical, and cyclotorsional diplopia.⁸⁻¹⁰ The diplopic images are perceived as being oblique or slanted, the amount being

Table 1 Bangerter filter densities

Filter density	Visual acuities*
1.0	~20/20
0.8	~20/25
0.6	~20/30
0.4	~20/50
0.3	~20/70
0.2	~20/100
0.1	~20/200
<0.1	~20/300

* Visual acuities predicted by manufacturer. Refers to visual acuity that each filter permits when placed over an eye with normal visual acuity.

incomitant. The cyclotorsion, which is best measured subjectively using the double Maddox rod test, can be substantial and prevent fusion when the horizontal and vertical components of the cyclovertical strabismus are offset with prisms in primary position in free space. These patients have been diagnosed erroneously as having horror fusionis without fusion potential.⁸ Fusion is usually seen when the patient is evaluated with the synoptophore, which offsets the cyclotorsion. Bangerter filters can be used while waiting for resolution or surgical treatment of the cyclovertical strabismus.

Case 2

A 52-year-old man was referred with a 1-year history of constant diplopia. In December 2007 he was in a car accident and suffered an orbital floor fracture in the right eye. Corrective strabismus surgery 1 month later did not eliminate the diplopia, which the patient described as being slanted. Examination found corrected vision of 20/20 in each eye with a refraction of -2.00 -1.00 x 2 in the right eye (O.D.) and -1.75 -0.50 x 155 in the left eye (O.S.). A compensatory head posture was not present. The patient manifested a 12-prism diopter (PD) right exotropia and

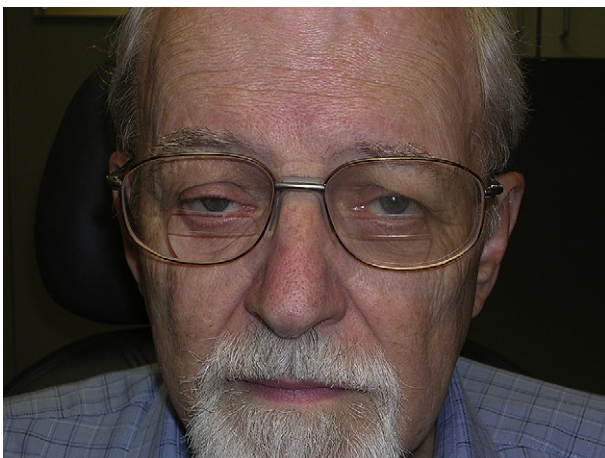


Figure 1 Patient with 0.6 Bangerter filter on left spectacle lens.

8-PD right hypotropia at distance in primary position, and a 6-PD right hypotropia at near. The exotropia increased in down gaze, and the hypotropia increased in up gaze. Version testing showed marked restriction of elevation in the right eye in all positions, more when looking up and to the left. Sensory testing with the Worth 4-dot test showed diplopia at both distance and near. Stereopsis was not present with the Randot Stereotest. With the double Maddox rod test, a total of 18 degrees of incyclotorsion (15 degrees O.D. and 3 degrees O.S.) was measured in primary position. Prisms compensating for the exotropia and hypotropia in primary position did not provide fusion. With the synoptophore, which offset the incyclotorsion, sensory fusion with stereopsis and limited fusional vergence amplitudes were seen. Because prisms were ineffective in neutralizing the incyclotorsion and establishing fusion in free space, and additional strabismus surgery was not in the near future, a 0.2 Bangerter filter over the right spectacle lens relieved the diplopia and was prescribed.

Diplopia caused by retinal disease

Displacement of the visual receptors of the retina caused by pathologies such as an epiretinal membrane, vitreoretinal traction, subretinal neovascularization, and central serous retinopathy results in the visual perception of objects appearing distorted. The image seen by one eye is a different shape from that seen by the other eye. When mechanical displacement of the affected fovea occurs, both foveas no longer have corresponding retinal points, and rivalry between central and peripheral fusion occurs. Strabismus and diplopia may develop in patients having surgical repair for macula-off retinal detachments.^{11,12} With compression or stretching of the retinal receptors, aniseikonia can also be induced because of the alteration in spacing between receptors.¹³⁻¹⁶

The diplopia produced by retinally induced aniseikonia gives 2 images that are not displaced in space but one image that is larger than the other. Micropsia occurs when the photoreceptors become stretched, whereas macropsia occurs when the photoreceptors become compressed. Unlike optically induced aniseikonia caused by anisometropia, retinally induced aniseikonia can be heterogeneous and vary in amount in different parts of the visual field.^{14,15,17} Bangerter filters can relieve the diplopia associated with retinally induced aniseikonia and metamorphopsia.

Case 5

A 74-year old man was referred for diplopia. The patient complained of the right eye image being much larger than the left eye image. He also noticed visual distortion, especially when reading and using his computer. According to the patient, some lines in the newspaper appeared double

Table 2 Clinical findings for adults treated with Bangerter filters

Case	Age/gender	History	Diagnosis/ocular alignment status	Refractive error/VA	Fusion present	Filter density	Comment
1	56/F	Head trauma; surgery for brain tumor; prism not helpful	Marked exocyclotorsion (23 degrees) associated with acquired bilateral superior oblique palsy; exotropia in upgaze and esotropia in downgaze	O.D.: -5.75 -2.50 x 20 (20/20) O.S.: -9.00 -2.25 x 170 (20/20)	Not tested	0.1	Ocular deviation improved over time; diplopia remains only at near
2	52/M	Orbital floor fracture caused by trauma; EOM surgery unsuccessful	Marked incyclotorsion (18 degrees) associated with restrictive cyclovertical strabismus; exotropia and hypotropia in primary position	O.D.: -2.00 -1.00 x 2 (20/20) O.S.: -1.75 -0.50 x 155 (20/20)	Yes (with synoptophore)	0.2	Patient preferred contact lenses instead of glasses
3	55/M	Macula-off retinal detachment repair in O.S.; cataract surgery O.S.	Retinally induced aniseikonia and metamorphopsia; exophoria	O.D.: -11.25 -3.25 x 10 (20/30) O.S.: -12.75 -3.75 x 135 (20/30)	Yes (stereopsis - 400 sec of arc)	0.6	4% - 5% image disparity in vertical and 12% image disparity in horizontal meridian, O.S. requiring the magnification. Patient uses RGP contact lenses
4	74/M	Retinal detachment surgery O.D. 15 years ago; cataract surgery O.D.; prism-in glasses	Retinally induced aniseikonia and metamorphopsia; orthophoria	O.D.: -0.50 -2.00 x 91 (20/20) O.S.: +1.50 -2.00 x 86 (20/20)	Yes (stereopsis - 200 sec of arc)	0.2	11% image disparity in vertical and 9.5% image disparity in horizontal meridian, O.S. requiring the magnification
5	74/M	Bilateral epiretinal membrane; diabetes; prism-in glasses not helpful	Retinally induced aniseikonia and metamorphopsia; orthophoria at distance and exophoria at near	O.D.: -1.00 -0.75 x 107 (20/40) O.S.: -2.25 -0.75 x 105 (20/50)	No	0.4	11% image disparity in vertical and 9% image disparity in horizontal meridian, O.D. requiring the magnification; small excyclotorsion

(continued on next page)

Table 2 (continued)

Case	Age/gender	History	Diagnosis/ocular alignment status	Refractive error/VA	Fusion present	Filter density	Comment
6	61/M	Pseudophakia O.D.; corneal surgery to eliminate diplopia; prism not helpful	Bilateral monocular diplopia; orthophoria	O.D.: -0.25 -1.00 x 139 (20/25) O.S.: Pl -2.50 x 70 (20/20)	Yes (stereopsis - 30 sec of arc)	0.6 over right spectacle lens (diplopia worse in O.D.)	Patient subsequently fit with rigid gas permeable contact lenses
7	58/F	Head trauma caused by car accident	Monocular diplopia; exophoria	O.D.: +0.50 -0.50 x 100 (20/20) O.S.: +0.50 (20/25)	Yes (stereopsis - 25 sec of arc)	0.4	Wears filter mostly for driving
8	45/M	4 surgeries for exotropia, the first at 4 years old and the last at 25 years old; extensive orthoptics from 4 to 12 years old. Diagnosed as having horror fusionis; treated previously with an opaque contact lens	Rapid alternating fixation associated with an apparent constant 12-PD exotropia at distance and constant 18-PD exotropia at near	O.D.: Pl - 1.00 x 73 (20/20) O.S.: -0.75 -0.75 x 75 (20/20)	Yes (stereopsis - 70 sec of arc, cannot fuse with compensatory prism)	0.4	Having patient maintain fixation with either his right or left eye without quickly alternating fixation reveals suppression of the contralateral eye
9	27/M	Cerebral palsy; strabismus surgery at 1 year old for probable infantile esotropia	Rapid alternating fixation associated with a bilateral and asymmetrical dissociated vertical deviation	O.D.: -1.00 - 0.25 x 140 (20/20) O.S.: -1.00 -0.75 x 170 (20/20)	No	0.6	Filter density changed to 0.4 at follow-up
10	44/F	Extensive patching for amblyopia during childhood	Rapid alternating fixation; small-angle esotropia	O.D.: +0.50 -0.25 x 115 (20/20) O.S.: +0.50 -0.25 x 115 (20/20)	No	0.3	Patient preferred filter over dominant eye

or shifted. The patient has diabetes. Ocular history was significant for bilateral posterior vitreous detachment, bilateral epiretinal membrane, and bilateral cataract. Prism treatment had been unsuccessful in the past.

The examination found a refractive error and corrected visual acuities for the O.D. -1.00 -0.75 x 107 (20/40) and O.S. -2.25 -0.75 x 105 (20/50). Metamorphopsia without a scotoma was present with the Amsler grid in both eyes. Cover testing showed orthophoria at distance and 7-PD exophoria at near. There was no change of ocular alignment status in any position of gaze. A 4-degree right excyclotorsion was measured with the double Maddox rod. Vertical diplopia was noted with the Worth 4-dot test. Stereopsis was not present with the Randot stereotest. New Aniseikonia Testing (Handaya Co. Ltd., Tokyo, Japan) found 11% disparity measured in the vertical meridian and 9% disparity measured in the horizontal meridian, the right eye perceiving the larger-sized image. With a 5% size lens (a lens of zero focal power that provides 5% magnification) before the left eye, reading was more comfortable for the patient.

The diagnosis was diplopia caused by retinal disease. It was presumed that more stretching of the retinal receptors had occurred in the left eye than the right eye, causing the image in the right eye to be perceived as being larger.¹³ Because the magnitude of the image disparity was substantial and not predicted by the amount of anisometropia in the patient's spectacle lenses, changing the magnification properties of the spectacle lenses to reduce the retinally induced aniseikonia was not feasible. A Bangerter filter (0.6) over the left eye was prescribed. Subsequently, the filter density was changed to 0.4, which was more acceptable.

At follow-up, dilated ophthalmoscopy and optical coherence tomography confirmed epiretinal membranes in both eyes with focal thickening of the left macula. Macular edema, more in the left eye, was also demonstrated. The patient was referred for possible epiretinal membrane peel in both eyes. In the meantime, he continues to use the Bangerter filter. Whether surgery would alleviate the retinally induced aniseikonia and diplopia is unknown.¹³

The patient subsequently underwent a pars plana vitrectomy and internal limiting membrane peel in the left eye, which significantly reduced the edema. Three months after the procedure, aniseikonia persisted, with micropsia in the left eye. The patient continues with the Bangerter filter.

Monocular diplopia

Approximately 12% of patients presenting with diplopia actually have monocular diplopia.¹⁸ Monocular diplopia (which occurs with only 1 eye open) can be unilateral or bilateral. Patients with monocular diplopia frequently describe perceiving a halo, ghost image, image overlapping, or *image stacking* rather than 2 separate and distinct images.¹⁸⁻²⁰ Causes of monocular diplopia are numerous and include 1) extraocular or ocular optical causes, such as uncorrected or improperly corrected refractive error

(especially astigmatism), incorrect placement of a bifocal segment, cataract, dislocated intraocular lens, corneal scarring from LASIK, keratoconus, ectropion, entropion, iris abnormalities, and tear film abnormalities; 2) organic causes, such as retinal disease, neurogenic disease, and migraine; 3) and psychogenic causes.¹⁸⁻²⁰ Monocular diplopia resulting from extraocular or ocular optical causes is the most common and disappears when the patient views through a pinhole.^{18,19} When the etiology is uncertain, or conventional treatment such as rigid contact lenses or adjusting the optical prescription do not alleviate the diplopia, Bangerter filters can be used.

Case 7

A 58-year-old woman was referred for a binocular vision evaluation. She had been in a car accident 10 months prior and suffered trauma to the left side of the head. Subsequently, she had experienced diplopia, described as "objects being vertically stacked."

The examination found visual acuities of O.D. 20/20 and O.S. 20/25 with a small refractive correction. Metamorphopsia was detected in the left eye with the Amsler grid. A 4-PD exophoria at distance and a 12-PD exophoria at near were measured with the alternate prism cover test. Version testing showed normal extraocular muscle function and absence of strabismus in all positions of gaze. With the Randot stereotest, 25 seconds of arc was measured. Further testing found that the "vertical stacking" was limited to viewing with only the left eye and disappeared with a pinhole.

The diagnosis was monocular diplopia in the left eye. A 0.4 Bangerter filter, which according to [Table 1](#) reduces acuity to approximately 20/50, placed over the left spectacle lens eliminated the monocular diplopia.

Follow-up 3 months later indicated absence of diplopia with the Bangerter filter. When removing the filter, diplopia persisted. Additional testing at that time to determine the cause for the monocular diplopia included optical coherence tomography, threshold visual fields, color vision, corneal topography, and dilated ophthalmoscopy. With the exception of visual fields in the left eye, which showed 3 clustered points, all findings were normal.

Diplopia caused by spontaneous and rapid alternating fixation

In adults having childhood-onset strabismus, spontaneous and rapid alternating fixation can mimic diplopia. The patient notices the shift in the apparent position of the fixation target when fixation rapidly changes from one eye to the other. This is perceived as diplopia. Observation of the rapid alternating fixation pattern by the clinician is essential for the diagnosis as well as correct interpretation of sensory tests. With the Worth 4-dot test, for example, 5 dots or lights (diplopia) will be perceived by the patient.

The clinician must question the patient regarding whether the 5 lights are perceived simultaneously or whether they change between 2 and 3 lights very quickly. Bangerter filters can be used to enforce a dominant eye and eliminate the diplopia caused by rapid alternate fixation.

Case 10

A 44-year-old woman was referred for diplopia, which reportedly began in childhood. The patient described the diplopia as being both horizontal and vertical. Ocular history was significant for extensive occlusion therapy in childhood for presumed amblyopia. According to the patient, she had been patched (either the right or left eye) during all waking hours for at least 3 years. She denied any other treatment.

The examination found visual acuities of 20/20 in each eye with a refractive error of O.D. +0.50 -0.25 x 115 and O.S. +0.50 -0.25 x 115. The patient manifested a constant, alternating 2-PD esotropia at distance and a constant, alternating 14-PD esotropia at near. The strabismus was comitant. Diplopia was noted by the patient with the Worth 4-dot test. Stereopsis was not present with the Randot stereotest. Although the synoptophore showed normal retinal correspondence, suppression prevented any fusion.

Careful observation indicated that the patient alternated fixation very rapidly between the eyes. Repeating the Worth 4-dot test found that the patient actually did not perceive diplopia simultaneously. Forcibly maintaining fixation with either eye resulted in suppression and the patient seeing either 2 or 3 lights.

The diagnosis was rapid alternating fixation mimicking diplopia. A 0.3 Bangerter filter over the right spectacle lens (nondominant eye) was prescribed. On follow-up 6 weeks later, the patient reported decreased diplopia with the filter but found wearing it annoying. Switching the filter to the left spectacle lens provided better comfort.

Discussion

Although not a cure, Bangerter filters can be useful for mitigating diplopia caused by cyclotropia, retinal disease, monocular diplopia, or spontaneous and rapid alternating fixation. Full opaque occlusion, opaque contact lenses,²¹ monovision contact lenses or spectacles,²² and opaque intraocular lenses²³ have been used to treat intractable diplopia. However, they do not allow peripheral fusion and a full peripheral visual field that low-to-moderate Bangerter filters provide.

The long-term treatment effect of Bangerter filters is unknown. The ultimate goal is to prescribe the weakest density filter that eliminates the diplopia and possibly taper the density of the filter to either partially or entirely over time. Some patients may learn to ignore the diplopia. Reports in the literature on series of adults treated with

Bangerter filters are infrequent.^{12,24,25} McIntyre and Fells²⁴ treated 24 patients using Bangerter filters, 14 having childhood-onset strabismus and 10 having adult-onset strabismus. The cause of the diplopia in the childhood-onset group was either spontaneous or attributed to strabismus surgery. In the adult-onset group, diplopia was caused by cranial nerve palsies, convergence paralysis, restricted ocular motility after retinal detachment surgery, or metamorphopsia. Prescribing prism did not eliminate the diplopia. McIntyre and Fells²⁴ used 5 outcome criteria to evaluate the efficacy of Bangerter filters. Excellent outcome occurred when the filters could be discarded over time without diplopia or only occasional diplopia occurring. Good outcome occurred when diplopia was eliminated using the lower-density filters (0.6, 0.8, or 1.0). Satisfactory outcome included using filter densities of 0.3 or 0.4 while fair outcome included using filter densities of 0.2 or 0.1. Unsatisfactory outcome implied nontolerance to the filters. With good, satisfactory, and fair outcomes, diplopia persisted without the filters. For the 20 patients who had follow-up, 4 had excellent, 5 had satisfactory, 4 had fair, and 7 had unsatisfactory outcomes.

Silverberg et al.²⁵ used Bangerter filters for 7 patients with small-angle vertical strabismus and diplopia induced by macular pathology such as subretinal neovascularization, epiretinal membrane, and central serous retinopathy. Neither prism therapy nor manipulation of the patients' refractive correction could eliminate the diplopia. Unlike the patients described who had diplopia caused by retinal disease in the current series case 5 and also cases 3 and 4 (see Table 2), aniseikonia was not reported by Silverberg et al.²⁵ Also, the patients in the current series did not have strabismus. Five of Silverberg's patients used a 0.6-density filter, 1 patient used a 0.4-density filter, and another patient used a 1.0-density filter over the affected or more affected eye. Two patients elected not to wear the filters. Follow-up ranged from 3 months to 44 months. Reducing the filter density at follow-up resulted in diplopia. Interestingly, Silverberg's patients maintained the same level of sensory fusion with the filters in place, with only 2 having reduced stereoacuity. During synoptophore evaluation with the filters in place, patients suppressed the affected eye while viewing foveal superimposition targets but did not suppress with macular and paramacular superimposition targets. Silverberg et al.²⁵ concluded the uniqueness of Bangerter filters lies in their ability to eliminate rivalry between central and peripheral fusion while inducing a functional central scotoma in the affected eye.

In the current study, the density of Bangerter filter used ranged from 0.6 to 0.1. Although Bangerter filters are designed to produce diffuse defocus that degrades visual acuity predictably, a wide range in visual acuity reduction may occur with the same density filter.^{4,5} Odell et al.⁴ recently reported the effect of Bangerter filters on 15 visually normal adults for different modalities of vision function and concluded that visual acuity degradation was inconsistent with the levels labeled by the manufacturer. There was no

systematic deviation from predicted values. The 1.0-, 0.8-, and 0.4-density filters degraded distance optotype visual acuity similarly, whereas progressive degradation in visual acuity occurred with the 0.3-, 0.2-, 0.1-, and < 0.1-density filters. In the current study, variability with the filters was apparent. With one patient, the 0.6 filter degraded visual acuity to 20/200, and for another patient the 0.6 filter degraded visual acuity to 20/50. For another patient, initial visual acuity with a 0.3 filter was 20/150, whereas 1 month later with the same filter in place, visual acuity was 20/80. Despite the variability with Bangerter filters, the weakest density filter that eliminates the diplopia should be given because that provides a better chance for maintaining any fusion. Odell et al.²⁶ determined that stereopsis became nil for visually normal adults with certain random dot stereotests when visual acuity was degraded to 20/63 with Bangerter filters. In the report by Silverberg et al.²⁵ one patient with visual acuity degraded to 20/100 while the filter still maintained stereopsis with the Titmus stereotest.

The blur induced by the filters may not be accepted by some patients as treatment for the diplopia. This may be more likely for patients who underwent retinal surgery that improved visual acuity but nevertheless acquired diplopia caused by retinally induced aniseikonia and metamorphopsia. According to McIntyre and Fells,²⁴ success with Bangerter filters is more likely in patients who are willing to accept this form of treatment as a means of eliminating the diplopia and who fully understand and comply with the treatment.

This report documents the use of Bangerter filters for patients with complicated types of diplopia caused by cyclotropia, retinal disease, monocular diplopia, and rapid alternating fixation. Prospective studies that determine the long-term effect of these filters, the visual acuity level and fusional level that is maintained with the filters, whether the filters can be tapered over time, and the quality of life with the filters would be helpful.

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