Extended Wearing Trial of Trifield Prism Visual Aid for “Tunnel Vision” Among Patients with Retinitis Pigmentosa or Choroideremia

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Abstract

Purpose: "Tunnel vision" (severely restricted visual fields) impairs mobility. We evaluated a novel spectacle-based prism device proposed to assist such patients[6,8].

Methods: To extend the visual fields, two prisms separated by a vertical junction (like a Franklin bifocal) were fitted apex-to-apex over one eye. The other eye had a conventional correction. This creates visual confusion (two different objects at the same apparent direction). Nine patients with advanced retinitis pigmentosa or choroideremia and an average visual field width of 12 ± 5 degrees wore the Trifield glasses for an average of 11 ± 6 weeks. Adaptation to the change in perceived direction of objects seen through the prisms, a perceptual integration of the Trifield device, was evaluated with a pointing task. The ability to navigate and walk safely in an unfamiliar shopping mall was also assessed. Perceived quality of life was evaluated using questionnaires (Rasch analysis[5]) before and after study.

Results: Visual field expansion with Trifield glasses was demonstrated using perimetry. Patients reported detection of obstacles that would otherwise be outside their visual field. However, generally they were unable to determine the location of the obstacle and we found no adaptation to perceived direction. With Trifield glasses, patients walked more slowly in the mall at the end of the study. There were no changes in mobility-related quality of life. At the end of the study, only 4 of 8 patients reported a benefit from Trifield glasses. It is possible that our study length did not provide sufficient time to adjust to the complex visual scene created by the Trifield glasses, particularly since patients only wore them about 0.5 hour per day. However, 10 ± 2 months after completing the study only 1 of 5 patients continued to use Trifield glasses.

Conclusions: Trifield glasses provided some benefit to some patients, by giving warning of nearby objects and aid in search for missing objects. However, the benefits were limited and only experienced by 4 out of 8 patients. Adaptation to binocular confusion is difficult even when it provides VF expansion.

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Background

Retinitis pigmentosa (RP) and allied diseases affect 1 of 4,000 people worldwide[2].

A severely restricted Visual Field (VF) or “tunnel vision” is a debilitating symptom of these diseases.

Tunnel vision severely impairs mobility, which reduces independence and quality of life[7].

The course of RP can be slowed with vitamin A supplementation[1]. There is no treatment for many allied diseases.

Trifield glasses combine a novel prism lens in one eye with a conventional lens in the fellow eye. This design employs Biocular, Temporal, and Spectral Mutliplexing to extend the binocular VF.

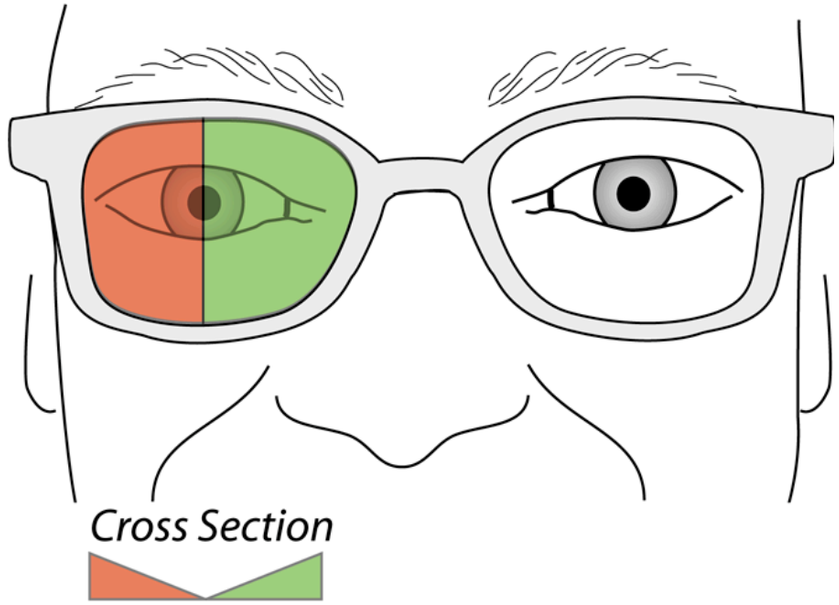
Prisms alter the perceived direction of objects.

With continuous wear, people can adapt to the change in visual direction[3].

This extended wear study assessed whether patients with tunnel vision benefit from Trifield glasses.

Design of Trifield Glasses

- **Biocular Multiplexing**: each eye receives information from different locations.
  - **Result:** a wider binocular VF.
  - For one eye, two prisms are positioned apex to apex along a vertical junction that bisects the pupil when the patient looks straight ahead. The fellow eye receives a conventional prescription lens.
  - The prism eye's VF is shifted laterally while the fellow eye's VF maintains its Visual Direction.
- **Temporal Multiplexing:** as the patient looks left or right, the prism eye looks through one prism at a time, hence VF expansion shifts with gaze.
  - **Result:** over time, more binocular VF expansion than with a single prism design.



- **Spectral Multiplexing:** Right prism is tinted RED, Left prism is tinted GREEN.
  - **Result:** patient receives information about the true direction of prism objects

Methods

Extended Wearing Trial:
- 7 Visits, 11 ± 6 weeks

Patients:
- Age = 49 ± 7 years
- 7 RP patients, 2 CHM patients
- Binocular VF = 12 ± 5 degrees
- VA = 0.20 ± 0.15 logMAR (20/32)

VF Expansion:
- Kinetic Perimetry

Adaptation to Visual Direction:
- Pointing task

Mobility Performance:
- Cognitive-mapping and way-finding in a large, complex shopping mall
- Traffic gap-detection at a busy intersection

Quality of Life:
- NEI Visual Function Questionnaire (NEI-VFQ)[4]
- Independent Mobility Questionnaire (IMQ)[7]

Clinical Success Interview:
- Benefits, Problems, Continue wearing Trifield glasses

Study Schedule

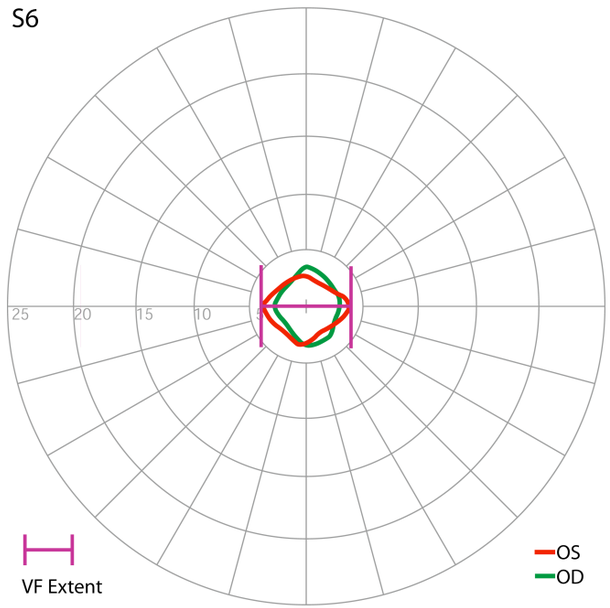
	Visit 1 -12.0 ± 2.7 Week	Visit 2 -5.0 ± 1.0 Week	Visit 3 0 Week	Visit 4 1.2 ± 0.4 Week	Visit 5 3.8 ± 3.0 Week	Visit 6 7.6 ± 3.0 Week	Visit 7 10.6 ± 6.2 Week
VF Expansion	X		X				X
Adaptation to Visual Direction			X	X	X		X
Mobility Performance		X				X	
Quality of Life	X						X
Clinical Interview	X		X	X	X		X

The Trifield glasses were dispensed at Visit 3 hence the visit timeline was defined relative to it.

Visits 1, 3, 4, 5, & 7 at SERI and MEEI. Visits 2 & 6 at the Arsenal Mall, Watertown, MA.

Visual Field Expansion

VF without Trifield

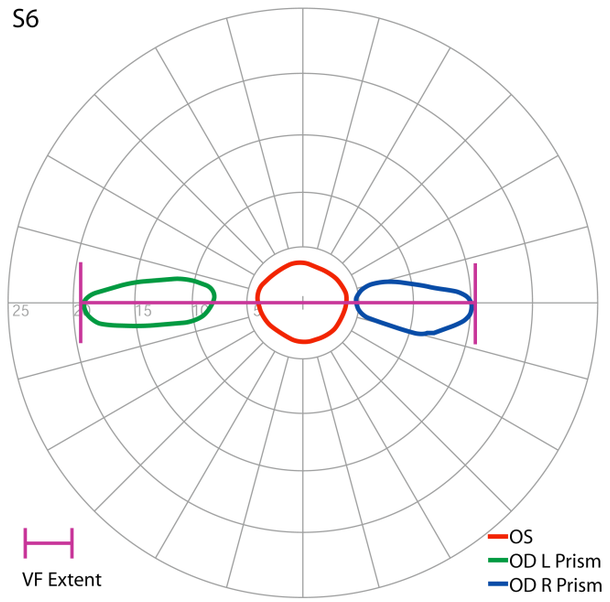


- Measured Monocularly
- Binocular VF = Distance from maximum monocular right radius to maximum monocular left radius

ID:	VF without Trifield (deg)	VF with Trifield (deg)	Ratio With/ Without
S1	7.5	20.0	2.7
S2	9.5	28.5	3.0
S3	16.0	29.0	1.8
S4	21.5	51.0	2.4
S5	15.0	24.0	1.6
S6	8.5	34.0	4.0
S7	16.5	41.0	2.5
S8	7.5	18.0	2.4
S9	10.0	28.0	2.8
Ave:	**12.4**	**30.4**	**2.5**

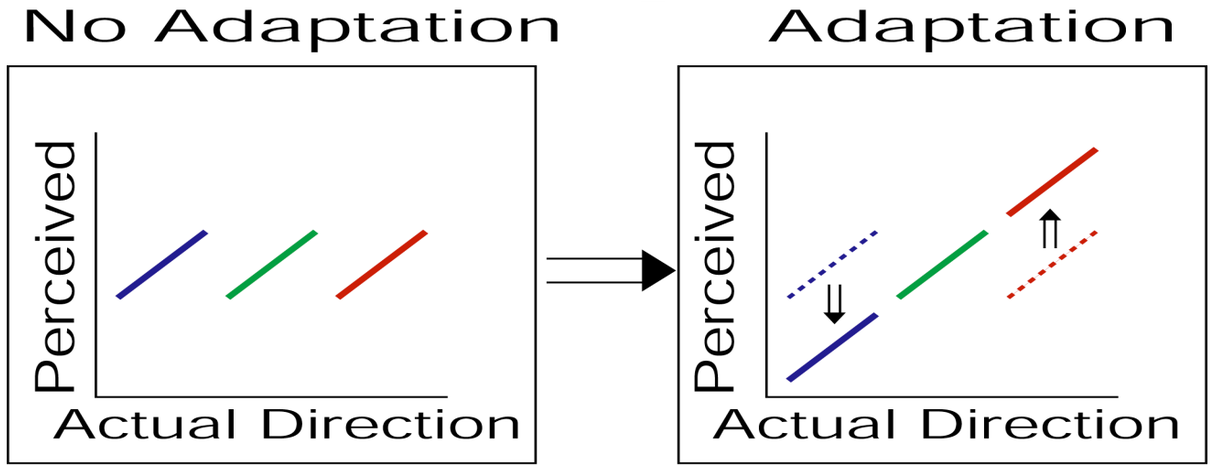
Trifield glasses provided substantial (~ 250%) VF expansion.

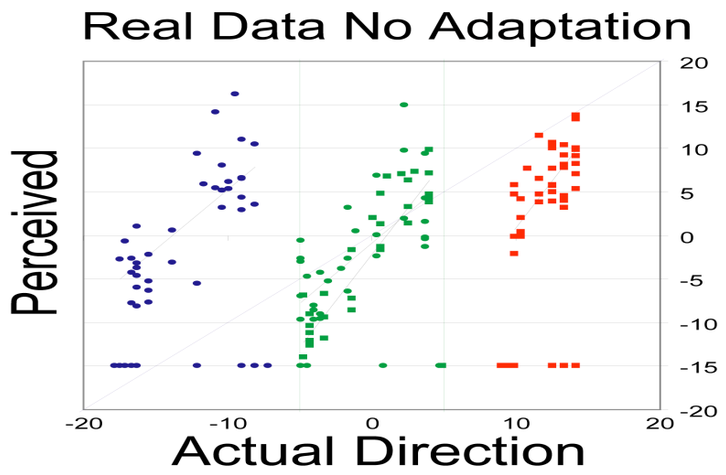
VF with Trifield



- Binocular VF = Distance from right edge of right prism VF to left edge of left prism VF
- Binocular VF results from temporal integration as the patient scans the environment

Adaptation to Visual Direction





- Subjects point to vertical line targets
- Linear fit of actual versus perceived location reveals 3 trends when Trifield is first prescribed
- Difference in Y-intercept measures change in Visual Direction, this difference reduces with Adaptation

Patients did not demonstrate adaptation to visual direction.

ID:	Prism Powers (deg)		Absolute Difference in Y-intercept (deg)			
			Visit 3		Visit 7	
	Right	Left	Right	Left	Right	Left
S1	8.5	9.6	3.5	6.2	1.8	5.4
S2	15.1	9.1	18.0	20.0	15.8	12.7
S4	27.0	19.8	11.7	32.0	18.0	28.3
S5	23.0	9.1	6.9	13.6	7.7	18.3
S6	24.0	10.2	5.8	25.0	24.9	49.4
S7	33.5	14.8	27.1	32.9	40.4	25.0
S8	7.5	9.1	18.0	3.3	10.1	12.9
S9	13.3	16.2	32.5	13.8	6.6	13.0

Quality of Life

Quality of Life was assessed at Visit 1 and at Visit 7 with the NEI–VFQ[4] and the IMQ[7].

VFQ and IMQ scores were transformed using Rasch Analysis[5].
Comparisons between Visit 1 and Visit 7 were made both by question and overall.

Although patients answered all questions, only mobility related questions were analyzed.
Example: **Because of your eyesight, how much difficulty do you have noticing objects off to the side while you are walking alone?**

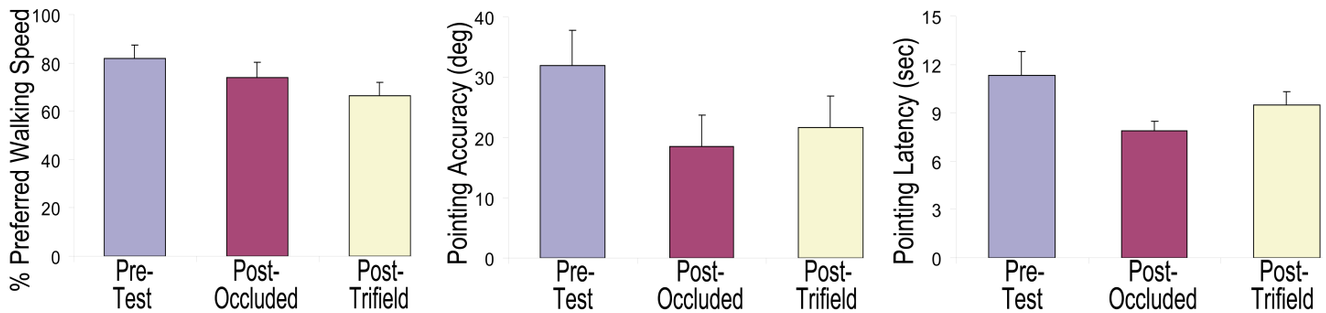
Non-mobility related questions were not analyzed.
Example: **Because of your eyesight, how much difficulty do you have picking out and matching your own clothes?**

No significant change in Quality of Life was measured.

Mobility Performance - Shopping Mall

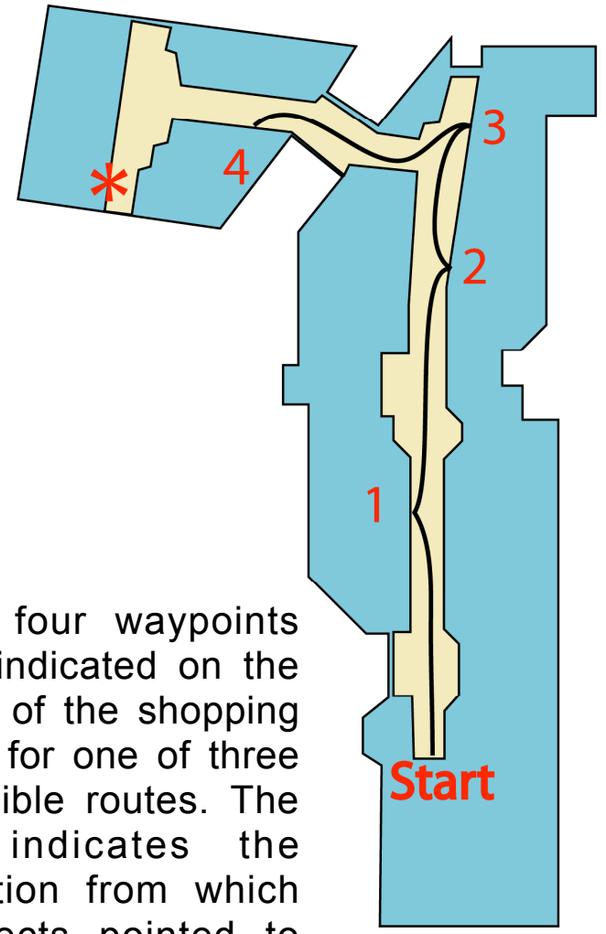
Question: Do Trifield glasses facilitate Way Finding and Cognitive Mapping?

Methods: *Way Finding:* search for and walk to 4 way points along 1 of 3 mall routes, stopping at each way point. *Cognitive Mapping:* at the end of mall walk, point from * to each waypoint.



- Pre-Test walking speed was significantly less than preferred walking speed ($t = -2.827$, $p = 0.03$)
- Post-Trifield walking speed was significantly less than Pre-Test ($t = -4.484$, $p < 0.01$) and Post-Occluded ($t = -2.501$, $p = 0.05$)

Apparent Differences in Way Finding were probably practice effects



The four waypoints are indicated on the map of the shopping mall for one of three possible routes. The * indicates the location from which subjects pointed to each of the four waypoints.

Clinical Success Interview

8 Patients were interviewed at the end of the wearing trial (Visit 7) and 5 were interviewed again 10 ± 2 months later.†

	Number who said Yes:	
Question:	**At End of Study:**	**10 months later:**
Will you continue to wear the glasses?	7 of 8	1 of 5
Did you benefit from the glasses?	4 of 8	2 of 5
Did you experience difficulties *because* of the glasses?	7 of 8	5 of 5
Would you pay $1000 for a pair of Trifield glasses?	Not asked	0 of 5

Patients wore the glasses for an average of 0.5 hours per week.
Patients experienced an average of 4.6 problems per week as a result of the glasses.

2 of 8 patients continue to wear Trifield glasses.††

† 8 of 9 Patients enrolled completed the trial, 3 of those 8 finished recently and will be interviewed again in the coming months.
†† This statement is based on all 8 who completed the trial. 1 of the 3 who has not been interviewed after completing the trial is very enthusiastic about the glasses. This patient wears the glasses regularly and would pay $1000.

Summary:

- Trifield glasses provided substantial VF expansion to all patients and limited benefit to some patients
- No patients demonstrated adaptation to visual direction
- No change in Mobility Performance or Quality of Life was measured
- 2 of 8 patients continue wearing the glasses

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