

## Binocular Amblyopia Therapies: A Potential Paradigm Shift

**B**inocular technologies are entering the market for the treatment of amblyopia. These innovative approaches are designed to improve VA, stereopsis, and binocular fusion. But how do they compare with the gold-standard monocular “penalization” therapies, patching and atropine? The reality is that study results have been mixed, and experts have questions as to whether these novel therapeutics can truly be considered a paradigm shift that will improve both monocular and binocular visual function.

### New Approaches

**Binocular therapy.** Traditionally, amblyopia has been treated as a monocular problem that subsequently affects binocular vision, said Justin D. Marsh, MD, at Eye Physicians of Central Florida, Maitland, Florida. “The paradigm shift behind these newer treatments is that perhaps we can treat the binocular system and achieve not only improvement in monocular vision but also in binocular function.”

Until about age 10, “the brain is actively making connections with the eyes and developing vision processing. These new binocular therapies may tap into an aspect of vision development that patching and atropine have not,” said Sudhi P. Kurup, MD, at Lurie Children’s Hospital of Chicago.

Laura B. Enyedi, MD, added that amblyopia changes the visual cortex.

“There’s a problem with visual input, but the amblyopia we’re treating is in the brain.” Whether the faulty input from the amblyopic eye is caused by strabismus, refractive error, or something that blocks the image like a cataract, she said, the brain suppresses input from that eye, depriving the visual cortex of normal development. “These new technologies have some advantages for potentially improving binocularity that we don’t see with patching.” Dr. Enyedi is at Duke University, Durham, North Carolina.

**Neuroplasticity.** Binocular therapeutics also tap into the evolving idea that neuroplasticity might last well beyond childhood.<sup>1</sup> An expanded horizon of cortical plasticity could also open the door to treat adolescents and adults. Because amblyopia is a common cause of monocular vision loss in adults, Dr. Enyedi said, “We would welcome treatments effective in adults, which we have not had to date.”

Dr. Kurup added that neuroplasticity has even been shown in the adult brain when it comes to vision processing. “In patients with stroke or hemifield vision loss for other reasons, prism therapy

can expand their visual field, so there’s evidence that the brain can reconnect to certain parts of vision.”

### Binocular Therapeutics

Of the multitude of new binocular therapeutics on the horizon for children, Luminopia, CureSight, and Vivid Vision will likely garner the most interest moving forward, said Dr. Marsh.

**Luminopia** (Luminopia, Inc.) uses a virtual reality headset with algorithms that modify the images in TV shows and movies, said Dr. Kurup. Reducing



**LUMINOPIA.** Luminopia is an FDA-approved binocular therapy that uses TV shows viewed through a virtual reality headset to improve vision in children with amblyopia. It uses dual-acting algorithms to modify the videos, teaching patients to use both eyes together to rebalance the input to the brain.

contrast to the stronger eye—and digitally masking parts of the video shown to each eye—forces binocular function to see the full video.<sup>2</sup>

In 2021, Luminopia was the first digital binocular therapeutic to get FDA approval for amblyopia due to anisometropia, said Dr. Marsh. It is indicated for children age 4 to 7.

A total of 105 children participated in the Luminopia phase 3 pivotal trial; all wore their glasses full time. The 51 children in the treatment group used the device for one hour daily, six days a week—“dosing” similar to standard-of-care patching for two hours daily. At 12 weeks, the Luminopia group gained 1.8 lines of VA in the amblyopic eye versus 0.8 lines in the glasses-only group.<sup>2</sup> Adverse events included headaches, eye strain, and dizziness.<sup>3</sup>

“Other randomized binocular studies were underwhelming,” said Dr. Marsh, but he noted that the Luminopia results were “very encouraging.”

Dr. Kurup, a participant in some of Luminopia’s research, began prescribing the device last year. “The Luminopia study showed an improvement in visual acuity compared with wearing eyeglasses, but this still needs to be tested in a head-to-head trial,” he said. “The real question is: is it noninferior or possibly better than standard-of-care patching?”

**CureSight** (NovaSight) uses eyeglasses with embedded eye-tracking technology that follows a child’s gaze and blurs the fovea of the stronger eye, spurring the visual cortex to merge the images together.<sup>1</sup> Kids use CureSight to watch standard movies and YouTube videos.

FDA 510(k) clearance came in late 2022 after the company released a noninferiority study compared to patching, said Dr. Marsh. He said that in the pivotal study,<sup>4</sup> “Kids were randomized to two hours a day of patching or 90 minutes a day of CureSight, five days a week. At 16 weeks, both groups improved a little over two lines, so my take is that this is a good alternative for patients not willing to patch.”

**Vivid Vision** (Vivid Vision, Inc.) patients play computer games—breaking bubbles or flying spaceships—while

wearing a virtual reality, head-mounted display.<sup>5</sup> Visual exercises and games include identifying specific 3D targets to use depth perception, an inherently binocular function, said Dr. Marsh. In the few small studies that have been completed, patients ranged from ages 3 to 69, and vision improved at least 1.5 logMAR lines.<sup>5</sup>

“It’s very different from patching or ‘penalization.’ It’s truly reinforcing the use of binocularity as opposed to blurring or decreasing contrast in the sound eye,” said Dr. Marsh. Although Vivid Vision lacks robust data and FDA approval, he added, “It’s a promising technology. I suspect at some point it will have a large randomized controlled trial.”

### More Efficacy Research Needed

**Varying results.** PEDIG’s early randomized controlled trials of binocular therapies for amblyopia, which looked at the “falling blocks” game and the Dig Rush game, “didn’t show very impressive results for improving visual acuity,” said Dr. Enyedi.

The Academy’s 2020 *Ophthalmic Technology Assessment* of binocular treatments,<sup>6</sup> including the falling blocks game, Dig Rush, iPad games, and others, also reported contradictory results: some patients had improved VA and some did not, and some therapies made vision worse compared with standard amblyopia treatment. A 2021 review of amblyopia technologies reported similarly ambiguous results.<sup>5</sup> And a 2023 review of emerging amblyopia technology covered 22 studies of various sizes, again with mixed results on efficacy.<sup>1</sup>

**Unanswered questions.** Many studies of new technologies have shown variability in results, said Dr. Enyedi, adding, “There’s still a lot of research to be done: what’s the best technology and dosage needed? How long-lasting are the effects and what’s the recurrence rate? Are these treatments effective for teenagers and adults?”

It would be helpful to have further studies showing head-to-head comparisons, said Dr. Kurup, “so we can start to understand which patients do well with which technologies.”

### Additional Concerns

**Cost.** Aside from efficacy, one of the biggest issues is cost, said Dr. Marsh. Cost goes beyond the technology itself, considering that there is potential need for extended or repeated treatments. “We don’t yet know treatment durability. If we’re stimulating the binocular system, is there less rebound amblyopia than with patching?” Also related to cost, Dr. Enyedi pointed out, “If Medicaid doesn’t cover these technologies, it will be an access and equity issue.”

**Screen time.** Dr. Enyedi added that the American Academy of Pediatrics and the Academy are recommending reduced screen time due to a variety of health concerns, including myopia progression associated with screen use. “These [binocular therapeutics] encourage kids to watch a screen instead of playing outside or interacting with others, which kids can do with a patch or atropine drops.”

1 Bui Quoc E et al. *Surv Ophthalmol*. 2023;68(3):507-525.

2 Xiao S et al. *Ophthalmology*. 2021;129(1):77-85.

3 FDA. [www.accessdata.fda.gov/cdrh\\_docs/reviews/DEN210005.pdf](https://www.accessdata.fda.gov/cdrh_docs/reviews/DEN210005.pdf).

4 Wagnanski-Jaffe T et al. *Ophthalmology*. 2023;130(3):274-285.

5 Boniquet-Sanchez S, Sabater-Cruz N. *Vision* (Basel). 2021;5(2):31.

6 Pineles SL et al. *Ophthalmology*. 2020;127(2):261-272.

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