Original Investigation

Evaluation of a Portable Artificial Vision Device Among Patients With Low Vision

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IMPORTANCE Low vision is irreversible in many patients and constitutes a disability. When no treatment to improve vision is available, technological developments aid these patients in their daily lives.

OBJECTIVE To evaluate the usefulness of a portable artificial vision device (OrCam) for patients with low vision.

DESIGN, SETTING, AND PARTICIPANTS A prospective pilot study was conducted between July 1 and September 30, 2015, in a US ophthalmology department among 12 patients with visual impairment and best-corrected visual acuity of 20/200 or worse in their better eye.

INTERVENTIONS A 10-item test simulating activities of daily living was used to evaluate patients' functionality in 3 scenarios: using their best-corrected visual acuity with no low-vision aids, using low-vision aids if available, and using the portable artificial vision device. This 10-item test was devised for this study and is nonvalidated. The portable artificial vision device was tested at the patients' first visit and after 1 week of use at home.

MAIN OUTCOMES AND MEASURES Scores on the 10-item daily function test.

RESULTS Among the 12 patients, scores on the 10-item test improved from a mean (SD) of 2.5 (1.6) using best-corrected visual acuity to 9.5 (0.5) using the portable artificial vision device at the first visit (mean difference, 7.0; 95% CI, 6.0-8.0; $P < .001$) and 9.8 (0.4) after 1 week (mean difference from the first visit, 7.3; 95% CI, 6.3-8.3; $P < .001$). Mean (SD) scores with the portable artificial vision device were also better in the 7 patients who used other low-vision aids (9.7 [0.5] vs 6.0 [2.6], respectively; mean difference, 3.7; 95% CI, 1.5-5.9; $P = .01$).

CONCLUSIONS AND RELEVANCE When patients used a portable artificial vision device, an increase in scores on a nonvalidated 10-item test of activities of daily living was seen. Further evaluations are warranted to determine the usefulness of this device among individuals with low vision.

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Low vision is a major disability and has obvious implications on patients' occupational and social lives. Patients with low vision have a lower quality of life.[1] In the absence of any medical measures to improve vision, aids for low vision and occupational therapy interventions can improve patients' quality of life.[2-4]

One portable artificial vision device (OrCam)[5] is an optical character recognition device, capable of recognizing text, monetary denominations, and faces, and can be programmed to recognize other objects. It is activated by the user either pointing, pressing a trigger button, or tapping on the device. The OrCam was recently made commercially available in the United States and is a potentially useful, intuitive, and interactive tool for patients with low vision (current price, $2500-$3500).

Interest is increasing among patients and physicians in portable electronic low-vision aids, and these devices warrant further evaluation.[6] The purpose of this study was to perform a preliminary evaluation of this portable artificial vision device's potential use in patients with low vision.

Methods

Patient Selection

This was a short-term prospective study that included patients with low vision seen in the Department of Ophthalmology and Vision Science, University of California Davis, Sacramento. The study protocol was approved by the University

Figure. Portable Artificial Vision Device

A OrCam unit mounted on glasses frame

B OrCam unit connected to the battery and computer pack

A, The OrCam unit, a miniature camera (on eyepiece of glasses), and a bone conduction earpiece (in front of ear) are mounted on the right side of a glasses frame. A cord connects the unit to a portable battery and computer pack. B, The OrCam unit connected to the battery and computer pack.

of California Davis Office of Human Research, and all participants signed an informed consent before inclusion. All patients were older than 18 years and were legally blind, with best-corrected visual acuity (BCVA) of 20/200 or worse in their better eye. Patients with low vision owing to any cause were included. Exclusion criteria included documented cognitive impairment and hearing loss since these conditions would prevent patients from using the OrCam. The study group consisted of 12 consecutive patients who met all inclusion criteria and consented to participate. Patients were recruited between July 1 and September 30, 2015.

Portable Artificial Vision Device

The OrCam unit includes a miniature camera and a bone conduction earpiece, which can be mounted to the right side of any spectacle frame (**Figure**, A). A cord connects the unit to a pack that houses the device's battery and computer. This pack can be held in the user's hand, clipped on a belt, or put in a pocket. It has 3 buttons that are recognized by touch (a button to turn the device on and off, a volume control button, and a trigger button) (Figure, B). The OrCam is portable and can be used anywhere. It can be activated by pressing the trigger button, by pointing at a target item, or by tapping the device. When activated, the OrCam takes a picture of whatever it is pointed at, which corresponds to where the user is facing. Using optical character recognition technology, the device then reads aloud any text found in the picture that was taken, which is heard only by the user via the earpiece and not by others nearby. The OrCam can also recognize monetary bill denominations and can be programmed to recognize faces and products. The device has some technical limitations: it cannot recognize special fonts and may be unable to recognize text if the contrast with its background is poor or under insufficient lighting conditions.

The units used in this study were supplied as a loan from the OrCam Company and were returned at its conclusion. The company was not otherwise involved in this study.

Key Points

Question Does a portable artificial vision device aid patients with low vision?

Findings In a prospective pilot study of 12 patients with visual impairment, results of a 10-item daily function test indicated an improvement in activities of daily living using a portable artificial vision device vs other available low-vision aids.

Meaning These results suggest that this portable artificial vision device may be an effective aid for patients with low vision.

Study Design

At the time of enrollment, patients underwent a 90- to 120-minute training session on the use of the OrCam by an experienced instructor (E.M.). After explanation of the device and its use, patients completed a 10-item test simulating daily functions. They were asked to complete these items 3 times: without using any low-vision aids, using their own low-vision aids if they had any, and using the OrCam. The patients were then given the portable artificial vision device to use in their regular settings for a week, along with the user manual and a telephone contact in case of any technical or operational difficulties. Patients were also called during the test week to make sure they were using the OrCam for at least 1 hour per day and to ask if they were experiencing any technical difficulties. After 1 week, patients returned to the clinic and completed the 10-item test again with the OrCam. After completion of the 10-item test, they also completed a questionnaire and provided feedback on the portable artificial vision device.

Daily Function Test and Questionnaire

The daily function test was developed for this study and was designed to include daily activities that are difficult for a patient with low vision and may be improved by the portable artificial vision device. These activities included reading from an electronic device, recognizing monetary bills, reading a newspaper article, finding a specific headline in a newspaper, reading a menu, recognizing a product, reading a letter, reading a page from a book, reading wall-mounted signs, and reading a distant sign. A detailed description of the test items is provided in **Table 1**. The patients' performance was monitored by an observer, and for each item, a score of 1 was given if the patient could complete the task and 0 if not, yielding a total score of 0 to 10 for each test. Patients took the test at the first visit without using any low-vision aids to establish their

Table 1. The 10-Item Functional Test[a]

Item No.	Detailed Description
1	Reading an email message displayed on an electronic device (smartphone or tablet computer). The patient was handed a device and asked to read aloud.
2	Recognizing money. Patients were given 3 different bills and asked to tell their value; 3 different bills were used each time, including $1, $5, $10, $20, and $100.
3	Reading a newspaper article. Patients were given a newspaper and asked to read aloud a specific article.
4	Finding a specific headline in a newspaper. Patients were given the front page of a newspaper and asked to find a specific story in it and read the headline aloud.
5	Reading a menu. Patients were given a menu from a local restaurant and asked to read it aloud and make a selection.
6	Product recognition. Patients were given 3 cereal boxes of similar size and shape but different brands and asked to tell them apart and identify each of them.
7	Reading a letter. Patients were given an envelope with a single-page letter in it and were asked to read it aloud.
8	Reading a page from a book. Patients were given a printed book (font size 11) and asked to open it and read a page aloud.
9	Reading signs on the wall. Patients were asked to find a specific room in a hallway by using the room number signs by the doors.
10	Reading a distant sign. A sign reading "STOP" was held 8 feet from the patients and they were asked to read it aloud.

[a] A score of 1 was given for each item successfully completed and 0 if not. The total score varied from 0 to 10.

Table 2. The 5-Item End-of-Study Questionnaire[a]

No.	Item
1	I found the OrCam to be simple to understand.
2	I found the OrCam to be easy to use.
3	I think the OrCam may be a useful tool to aid patients with low vision in daily life.
4	If available, I would use the OrCam in my daily life.
5	I would recommend OrCam to other patients with low vision.

[a] For each item, patients were asked to choose a score from 1 to 5, where 1 indicates strongly disagree; 2, somewhat disagree; 3, neither agree nor disagree; 4, somewhat agree; and 5, strongly agree.

baseline ability, then with any low-vision aids they had, with the OrCam, and again after 1 week with the OrCam.

At the end of the study, patients also completed a short satisfaction survey on their experience with the portable artificial vision device (**Table 2**). The 10-item test and questionnaire were developed for this study and are nonvalidated.

Statistical Analysis

A paired 2-tailed *t* test was used to compare means of test scores taken with and without the OrCam and at different times. Pearson correlations were used to determine associations between parametric variables. Data were analyzed using SPSS for Windows, version 17 (SPSS, Inc).

Results

Twelve patients were included in this pilot study: 6 men and 6 women, with a mean (SD) age of 62.0 (18.6) years (range, 27-93 years). Causes of low vision were diverse and included a variety of corneal, retinal, and optic nerve diseases. A summary of the patients' ocular pathologic conditions and BCVA is provided in **Table 3**.

Test Results at First Visit

At the first visit, all participants completed the 10-item test without use of any low-vision aids, using only their eyeglasses to establish their baseline BCVA. The mean (SD) test score was 2.5 (1.6) (range, 0-5). None of the patients could perform 5 of the tasks, which included reading a message on an electronic device, reading a newspaper article, reading a menu, reading a letter, and reading a page from a book. In contrast, 11 patients (92%) could recognize bill denominations, 8 (67%) were able to locate a specific room in a hallway by using wall-mounted signs, and 7 (58%) were able to recognize products and tell the difference between similarly shaped and sized cereal boxes. Higher test scores were correlated with BCVA of the better-seeing eye (R = 0.77).

After initial instruction on using the OrCam, all participants completed the 10-item test using the device. The mean (SD) test score significantly improved to 9.5 (0.5) (range, 9-10), for a mean difference of 7.0 (95% CI, 6.0-8.0; P < .001).

Seven participants (58%) also completed the 10-item test using available low-vision aids that they use in daily life, including magnifying lenses, electronic magnifiers, and smartphone applications for reading text. For these 7 patients, the mean (SD) test score using low-vision aids was 6.0 (2.6) (range, 2-9), which was significantly improved vs their scores without using these aids (mean [SD], 3.0 [1.6]), for a mean difference of 3.0 (95% CI, 0.5-5.5; P = .02). Using the portable artificial vision device, these 7 patients' mean (SD) test scores improved to 9.7 (0.5), which was significantly better than both the baseline score (mean improvement, 6.7; 95% CI, 5.3-8.1; P < .001) and the score achieved with the use of low-vision aids (mean improvement, 3.7; 95% CI, 1.5-5.9; P = .01).

Test Results at End of Study

After using the OrCam for 1 week, the mean (SD) score on the 10-item test was 9.8 (0.4) (range, 9-10). This result was significantly better than the baseline score (mean difference, 7.3; 95% CI, 6.3-8.3; P < .001) but no different than the score achieved using the portable artificial vision device at the first visit (mean difference, 0.3; 95% CI, 0.1-0.7; P = .16).

Only 1 report of a technical difficulty was made during the study. Participants' responses on the questionnaire indicated that they found the OrCam to be simple to understand (mean [SD] score, 3.9 [1.1] of a possible 5), easy to use (4.1 [0.9]), and a useful aid in daily life (3.9 [0.7]). They reported that they would use it in their daily lives (3.1 [1.3]) and would recommend it to other patients with low vision (3.9 [1.3]).

Discussion

Patients with low vision are often dependent on aids to maximize their ability to orient themselves and perform activities of daily living. Technological advances have led to the development of many types of low-vision aids that do not rely on

Table 3. Patient Characteristics

Patient No./ Sex/Age, y	Cause of Low Vision	BCVA	
		OD	OS
1/F/73	Keratoconus; had undergone multiple penetrating keratoplasties and keratoprothesis in both eyes	20/400	CF
2/F/56	Retinitis pigmentosa	LP	LP
3/F/37	Stargardt disease	20/400	20/200
4/F/70	Congenital aniridia keratopathy; had undergone multiple penetrating keratoplasties and keratoprothesis in both eyes	CF	20/200
5/M/62	Stargardt disease	20/400	20/400
6/F/93	Age-related macular degeneration	CF	HM
7/M/27	Retinitis pigmentosa	HM	CF
8/F/63	Severe myopic degeneration	20/400	CF
9/M/86	Age-related macular degeneration	CF	20/200
10/M/60	Recurrent multiple retinal detachments in both eyes	20/200	20/400
11/M/49	Best disease	CF	20/400
12/M/68	End-stage glaucoma	20/400	20/400

Abbreviations: BCVA, best-corrected visual acuity; CF, counting fingers; HM, hand motion; LP, light perception.

lenses for magnification, such as electronic magnifiers, digital image processing tools, and optical character recognition.[7] Over the past 3 decades, although the demographics of patients with low vision have remained constant, the number of spectacle-mounted optical devices has declined in correspondence with a rise in availability of newer technologies and electronic devices.[8]

Our results indicate that the OrCam is an effective low-vision aid that is simple to understand and easy to use. In this study of 12 patients with low vision using a nonvalidated 10-item test, we found that, after an initial training session, patients were able to perform tasks simulating those of daily living significantly better when using the portable artificial vision device. There was a difference in the patients' ability to perform the test items when using the OrCam compared with using only their BCVA and no other aid. Unaided, no patient was able to read a message on an electronic device, a newspaper article, a menu, a letter, or a page from a book, which are all common activities impeded by low vision. The only item that most patients could perform by using only their BCVA without any other aid was recognizing monetary bill denominations since, at present, the monetary denomination is marked by a large, more easily recognized figure at 1 corner of the bill. Using the OrCam, all patients could perform at least 9 of the 10 items on the test, demonstrating the efficacy and usefulness of the device for them.

Limitations of this study include its sample size of 12 and the use of the 10-item test, which is not validated. However, we developed the test for this study and used it because we believe it allowed for a more robust evaluation of visual functions than a test that focuses on parameters, such as reading speed only. This assessment may be better to evaluate the broader functionality in activities of daily living when using the portable artificial vision device as an aid to patients with low vision. In addition, to prevent a learning effect that could bias the results in favor of the OrCam, test items were delivered in a random order, and the portable artificial vision device was not always the last to be tested. It is difficult to determine from this study if patients would be satisfied with this device. With only 12 individuals evaluated in this study, even if none of the participants were dissatisfied, one could be reasonably confident (95% of the time) that the true rate of dissatisfaction in the population is no more than 25%.

In a separate subanalysis of 7 patients who were using other low-vision aids, we found that their test scores were better when using the OrCam at the first visit than when using their previous low-vision aids. This finding suggests that the portable artificial vision device may have advantages over other low-vision aids.

Most studies on electronic low-vision aids have used reading speed as the primary outcome measure. In most of these studies, reading speed was faster using stationary devices than with head-mounted devices.[9,10] The methods used in our study provide a broader assessment of the OrCam as a low-vision aid since it is not focused solely on reading but on a broader range of visual functions. Stationary magnifiers and reading aids are usually heavy and remain in the patients' homes, while the OrCam is a highly portable device that individuals can take anywhere. In addition, reading speed is not an issue since optical character recognition technology recognizes text immediately, and the speed at which it is read aloud can be controlled and adjusted by the user.

This portable artificial vision device may have advantages in addition to text recognition and reading at normal speed. It may enable the user to recognize products, distant signs, and even faces. Using BCVA, only 7 patients (58%) could recognize a specific brand of cereal by its box compared with all 12 patients when using the OrCam. A sign held 8 feet away was only recognized by 1 patient (8%) without the portable artificial vision device compared with 11 patients (92%) when using the device. The fact that optical character recognition is immediate with the OrCam may also allow users to function at a "physiological" speed. For example, even when the patient with low vision can recognize monetary denominations using BCVA, he or she must turn the bill right side up and hold it very close to the eyes, while the OrCam user can recognize it faster, from a greater distance, and in any orientation (**Video**).

Conclusions

This pilot study demonstrates that the portable artificial vision device may be an effective low-vision aid. It is highly portable and intuitive to use and may be more effective than other low-vision aids available to these patients. We believe it may be a useful tool for patients with low vision that may allow them to enjoy improved functionality and independence.

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Acquisition, analysis, or interpretation of data: Moisseiev.
Drafting of the manuscript: Moisseiev.
Critical revision of the manuscript for important intellectual content: Mannis.
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Additional Contributions: The OrCam units used in this study were loaned to the department by the OrCam Company and were returned at the conclusion of the study. We thank the patients for granting permission to publish this information.

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