Near Visual Acuity for Everyday Activities With Accommodative and Monofocal Intraocular Lenses

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ABSTRACT

PURPOSE: To determine the levels of functional near visual acuity required for everyday social reading activities and to compare the levels to those attained with accommodative and monofocal intraocular lenses (IOLs).

METHODS: Font size equivalencies of an Early Treatment Diabetic Retinopathy Study near chart and a variety of commonly read print objects were determined and correlated to the findings of distance-corrected near vision measurements with 2 accommodative (Tetraflex, 1CU) and 1 monofocal (Acrysof MA30) IOLs.

RESULTS: The smallest print objects studied were sweetener packets with type between 20/40 (Jaeger [J] 5) and 20/50 (J6). Type in classified ads, stock quotations, and pocket bibles was 20/50 (J6), type in a telephone directory was 20/63 (J8), and type in standard newspapers, journals, and magazines was 20/80 (J9). Tested monocularly, 88% of Tetraflex, 40% of ICU, and 7% of Acrysof MA30 eyes had distance-corrected near vision sufficient to read newspaper and telephone directory print, and 63% of Tetraflex, 30% of 1CU, and 0% of Acrysof MA30 eyes could read classified ads, stock quotations, and pocket bibles, respectively. Tested binocularly after bilateral implantation, 96% of Tetraflex patients could read telephone directory print and 89% could read ads, stock quotations, and pocket bibles.

CONCLUSIONS: Functional near visual acuity is not equivalent to the bottom-line objective at 20/20 (J1) near visual acuity. No print size was found at or smaller than 20/40 (J5), indicating that a requirement of nearly perfect near visual acuity, while desirable, may not be necessary for patients' social reading needs for accommodative IOLs. [*J Refract Surg.* 2007;23:747-751.]

Today's patients have high demands regarding any kind of lens surgery. New medical technologies not only should be clinically effective but also should result in outcome benefits in terms of patient function, satisfaction, and quality of life. Despite the excellent restoration of visual acuity in cataract surgery, there is no accommodation in pseudophakic eyes, and most patients remain presbyopic using standard monofocal intraocular lenses (IOLs).[1]

Multifocal and bifocal IOLs were designed to address the lack of accommodation in monofocal lenses. These lenses provide a reasonable alternative to patients seeking both distance and near vision. Studies have shown that whereas multifocal IOLs provide good functional vision without the use of spectacles and/or corrective lenses, they also show evidence of contrast sensitivity loss as well as additional symptoms of glare disability and halos.[2-8] These optical disadvantages cause difficulty in key activities such as night driving, thereby decreasing the number of candidates for this type of IOL. This loss of image quality can affect visual performance and lead to a reduction in patients' quality of life.

An interest in alternative methods for providing patients with both near and distance vision has stemmed from the inherent optical problems of multifocal IOLs. The evolution of accommodating IOLs without the limitations of multifocal IOLs is an important trend; however, accommodative IOLs frequently do not demonstrate the crisp level of near vision acuity that can be found with multifocal lenses, which are effectively machined to provide a near focus.

This leads to an inquiry involving the near vision requirements of the majority of IOL recipients. Do patients need to

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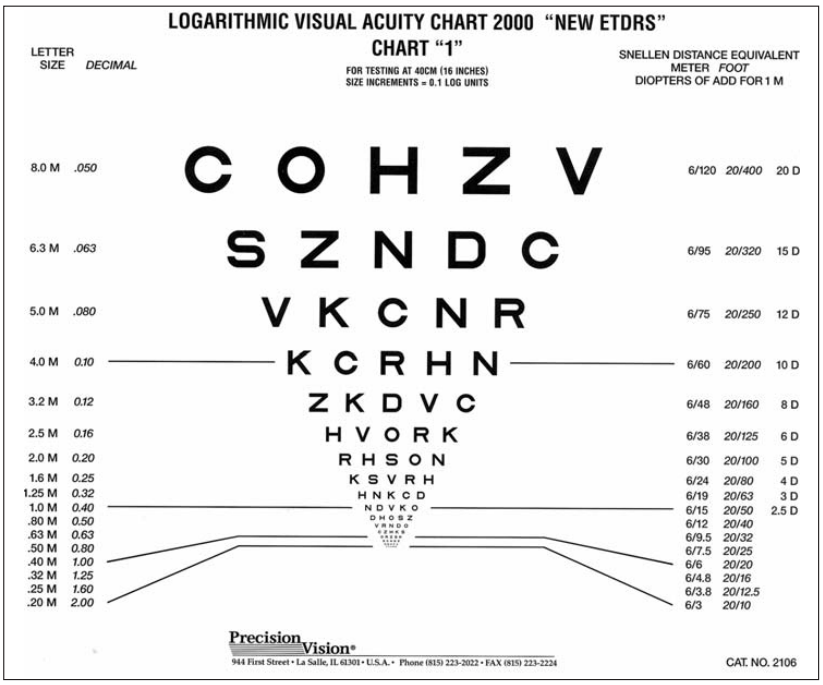

Figure. Standard Logarithmic Visual Acuity Chart 2000 "New ETDRS" Chart "1" used to compare the visual acuity needed for reading various print objects (ETDRS = Early Treatment Diabetic Retinopathy Study). (Reprinted with permission from Precision Vision.)

obtain 20/20 (Jaeger [J] 1), 20/25 (J2), or even 20/32 (J4) near vision acuity for everyday social reading and activities? The purpose of this study was to determine what reasonable near acuity measurement or print size would be needed to provide patients with social reading and whether the current generation of accommodative IOLs would be able to provide this level of functional acuity in a reasonable proportion of cases.

MATERIALS AND METHODS

Seven different categories of commonly read print objects were compared. Print objects included diverse examples of classified ads, stock quotations, standard newspapers, a telephone directory, journal and magazine articles, sweetener packets, and two pocket-size bibles.

Both local (*Chicago Tribune* and *Chicago Sun-Times*) and national newspapers (*The Wall Street Journal* and *USA Today*) were tested to rule out any discrepancies between newspapers. Classified ads were located within *USA Today* and both local newspapers. Stock quotations were tested within both the *Chicago Sun-Times* and *The Wall Street Journal*. A standard local Yellow Book USA was used for the telephone directory exhibit. The *Journal of Refractive Surgery, American Journal of Ophthalmology, People,* and *US News & World Report* were used as templates to measure the font size of journal and magazine articles. Nutritional information from the back of sweetener packets (Splenda, Sweet'N Low, and Equal) also was tested, along with two pocket-size (2×4 inches) bibles. The smallest print found on the classified ads, stock quotations, telephone listings, and sweetener packets was used. These print sizes were compared to a logMAR visual acuity near chart (Early Treatment Diabetic Retinopathy Study [ETDRS], Chart "1"; Precision Vision, La Salle, Ill) (Fig).

The logMAR charts use Sloan letters, a customized font not used with commonly read print objects.[9] These visual acuity charts facilitate quantitative use of vision results by standardizing the measurements of visual acuity. Because the ETDRS chart uses a customized font style, an absolute comparison of font style cannot be made to print objects found in daily reading activities. Therefore, the font used for comparison was Times New Roman because it is one of the most widely used fonts in newspapers and books.[10] When evaluating the Times New Roman font sizes, we focused on the height of the letters because the width of letters is more variable than the height of letters between fonts of the same numeric font size. Capital letters in the print objects and the logMAR chart were compared because the logMAR chart only uses capital letters.

To compare the visual acuity needed to read the objects in question to that of the ETDRS chart, Microsoft Word (Microsoft Corp, Redmond, Wash) was used to find the Times New Roman (original) font size with

TABLE 1

Font Size Equivalencies to Visual Acuity

Font Size*	ETDRS Chart Visual Acuity	Jaeger	Print Object
12	20/100	J10	
9.5	20/80	J9	Standard newspapers, journals, and magazines
7.5	20/63	J8	Telephone directory
6	20/50	J6	Classified ads, stock quotations, bibles
5.5	—	—	Sweetener packets
4.5	20/40	J5	†
3.5	20/32	J4	†
3	20/25	J2	†
2.5	20/20	J1	†

ETDRS = Early Treatment Diabetic Retinopathy Study
**Times New Roman.*
†*No print objects were found for this font size.*

a height that correlated as closely as possible to each line on the ETDRS vision chart. We were able to easily distinguish visually between font heights with as little as a 0.5 difference in size. Because Microsoft Word does not allow the user to input font size in increments smaller than 0.5, we were unable to examine whether a smaller increment could be discerned visually. After finding the font size equivalencies, a simple handheld, adjustable focus, 8× stand magnifier was used to compare the Times New Roman font sizes to the print size in the commonly read print objects.

We obtained early (6 month) unpublished clinical data for a new accommodative IOL (Tetraflex Lens; Lenstec Inc, St Petersburg, Fla). Near vision with the patient's distance correction in place (distance-corrected near vision) was obtained at 6 months postoperatively, measured monocularly in 77 eyes and binocularly in 28 bilaterally implanted eyes; this series had 80% follow-up of patients at 6 months or later. These data were compared to distance-corrected near vision data from a monofocal control (Acrysof MA30; Alcon Laboratories Inc, Fort Worth, Tex [n=30]) series and another accommodative IOL (1CU; HumanOptics AG, Erlangen, Germany [n=30]) reported in the peer-reviewed literature.[11] Distance corrected near vision was used instead of uncorrected near acuity because it corrects for differences in postoperative refractive error between case series and better evaluates the ability of the IOLs to accommodate. In both the Tetraflex and literature series,[11] near acuities were taken at 40 cm distance using a Jaeger near card under photopic lighting conditions.

Significance of the difference in distance-corrected near vision values between IOL lens design groups was determined using the Mann-Whitney test, which is a nonparametric two-sample test applicable for unequal sample sizes in each group. A probability ⩽5% ($P<.05$) was considered statistically significant. The statistical procedures were run on StatXact4 (Cytel Inc, Cambridge, Mass).

RESULTS

Table 1 demonstrates the sweetener packets had the smallest print size we could find; all brands had the same size print, which was between 20/40 (J5) and 20/50 (J6). Standard newspaper print, stock quotations, and classified ads from the various newspapers were identical in terms of print size. Classified ads and stock quotations were 20/50 (J6) print size as were the two pocket-size bibles. The telephone directory print size was 20/63 (J8), and newspaper, journal, and magazine print size was 20/80 (J9), except for the *American Journal of Ophthalmology*, which had an even larger font height. We could find no commonly read print objects with a font height of 20/40 (J5) or smaller.

Seven percent of cases in the monofocal IOL control group and 40% of the 1CU accommodating lens referenced in the literature[11] could see fonts with heights corresponding to 20/63 or better with their distance spectacle correction in place, which would have allowed these patients to see type in a telephone directory or a newspaper (Table 2). In contrast, 88% of the Tetraflex cases could see this well with their distance spectacle correction in place and 63% (versus zero for the monofocal control and 30% of the 1CU lens cases) could see all of the print sizes studied when tested

TABLE 2

Comparison of Functional Acuity for Monofocal Acrysof, 1CU, and Tetraflex IOLs

	Percentage of Cases Able to Read Print Size*			
Print Object or Size	**Monofocal Acrysof IOL (n=30)[11]†**	**1CU IOL (n=30)[11]†**	**Tetraflex IOL (n=77)†**	**Tetraflex IOL (n=28)‡**
Standard newspapers, journals, and magazines, 20/80 (Jaeger [J] 9)	7	40	88	96
Telephone directory, 20/63 (J8)	7	40	88	96
Classified ads, stock quotations, bibles, 20/50 (J6)	0	30	63	89
Sweetener packets	0	30	63	89
20/40 (J5)	0	17	63	89
20/32 (J4)	0	17	26	68
20/25 (J2)	0	7	12	28
20/20 (J1)	0	3	1	4

**Distance-corrected near acuity.*
†Monocularly.
‡Binocularly.

monocularly. If patients were implanted bilaterally and tested bilaterally, then 96% of the Tetraflex cases could read the newspaper and magazine print size and 89% of patients could see all of the print sizes that were evaluated. Despite the relatively small sample size within each group (between n=28 and n=77), the proportion of cases able to read each size letter among the three IOLs and between monocularly and binocularly tested Tetraflex cases was so disparate that the differences among groups can be demonstrated to be significantly different from each other. Heatley et al[11] reported a highly significant difference between the monofocal control (Acrysof) and the 1CU IOL (P=.004), which we corroborated. The difference between the 1CU and the monocularly tested Tetraflex was significant at P=.0004, and the difference between the monocularly tested and binocularly tested Tetraflex was significant at P=.0002. Thus, the Tetraflex performed better than the 1CU IOL, which in turn performed better than the Acrysof monofocal IOL when tested monocularly. Similarly, the Tetraflex IOL tested binocularly performed better than with monocular testing.

DISCUSSION

Wolffsohn and Cochrane[10] developed an eye chart using Times Roman print with the progression and spacing of a standard logMAR chart and demonstrated a high correlation (r=0.97) between the results with that chart and a standard logMAR chart. Furthermore, they demonstrated near acuity measured with their new chart correlated highly to the ability to read newsprint (r=0.87, P=.001). Thus, although various factors can have an effect on the visibility of print including but not limited to a decrease in luminance, a decrease in contrast, the quality of paper, and the style and customization of font, their findings, taken together, tend to validate the findings of our study.

There is a great interest among patients and ophthalmologists (on behalf of their patients) to provide cataract surgical candidates with the option of an IOL that offers clear vision at both near and distance. The accommodative IOLs have been and are being designed to meet these needs in the cataract surgery field.

The two accommodative IOLs compared in this study differ slightly in design and material. The Tetraflex accommodating posterior chamber IOL is currently one of only two accommodative IOLs in clinical trials within the United States. The Tetraflex accommodative IOL is a single-piece IOL with extremely flexible 10° anteriorly angulated "closed loop" haptics. The Tetraflex IOL is manufactured completely from medical-grade hydroxyethylmethacrylate (26% water content) and a polymerizable ultraviolet blocker. With regard to mechanism of action, while there may be a component of anterior movement with accommodation, aberrometry demonstrates a widened refractive range and areas of increased myopia in the refraction maps with accommodative effort relative to the appearance of refractive maps when looking at a distant object. The 1CU accommodative IOL is a single-piece hydrophilic acrylic posterior chamber IOL with a 5.5-mm optic and four modified haptics designed to allow

anterior movement with accommodation. The 1CU is commercially available in Europe and is not in clinical trials in the United States.

The early clinical Tetraflex data (unpublished data) used in this comparison was too small of a sample (n=77) to truly demonstrate safety; however, 98.7% had a best spectacle-corrected distance vision acuity of 20/40 or better postoperatively, and no IOL-related complications were observed. The Tetraflex accommodating lens provided enhanced near vision relative to a monofocal IOL.

The trade-offs between an accommodative and a multifocal IOL are clear. Although multifocal IOLs allow excellent near vision without the use of spectacles, they can result in detrimental photic phenomena caused by a simultaneous superimposition of images on the retina. These include loss of clarity, loss of low-contrast acuity, and complaints of halo and glare. In addition, intermediate visual acuity with multifocal IOLs may in some cases be worse than that obtained with monofocal IOLs.[12] Alternatively, the accommodative IOLs do not have these limitations and give high-quality intermediate and distance vision without distortion in images because only one image at a time is formed on the retina.[13]

Patients have a variety of preferences and needs in regard to their daily lives. Emphasizing the importance of reading for personal convenience in everyday life is crucial to understanding patients' needs in terms of IOLs. The focus should be that of improving near vision-related activities including but not limited to reading newspapers, magazines, telephone books, and various labels. Although the near vision acuity level of the accommodative lenses is not as crisp as the multifocal IOLs, they do restore functional near vision to the majority of patients. Most patients receiving an IOL select a lens based on their need for near and far correction according to their everyday behavior. With the Tetraflex lens, as an example of the present generation of commercially available accommodative IOLs, it has been shown that a large percentage of patients possess the near vision acuity necessary to read virtually all social (daily) reading materials without the use of spectacles (88% could read all standard newspaper print [20/80] monocularly and 96% binocularly).

Patients would prefer reasonable everyday reading ability with the implantation of an IOL. If personal requirements include common reading materials, the accommodative IOLs allow effective functional reading given that we were unable to find any commonly read print size that would require 20/40 vision acuity or better. Although common wisdom may suggest next to perfect 20/20 (J1) near vision acuity is a compulsory goal in regard to implementation of accommodative IOLs, our findings show no common print object's font size is small enough to necessitate this level of acuity. Individual patient needs must be evaluated to determine whether crisp, precise near vision possibly accompanied by visual symptoms, as seen with multifocal IOLs, or acceptable "social reading" vision without these symptoms, as seen with accommodative IOLs, is required.

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