# EYE GROWTH IN THE SECOND DECADE OF LIFE: IMPLICATIONS FOR THE IMPLANTATION OF A MULTIFOCAL INTRAOCULAR LENS

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## ABSTRACT

*Purpose:* There is a growing interest in multifocal intraocular lens (IOL) implantation in children because they lose accommodation when a cataract is removed. Many have assumed that very little, if any, eye growth occurs in the second decade of life. Multifocal IOL implantation requires precise biometry to arrive at the correct IOL power for spectacle independence. If the eye grows and the refraction becomes myopic, spectacle dependence may return. Therefore, knowing when the eye has completed its growth is critical to the decision of when to implant a multifocal IOL.

*Methods:* Ninety-eight eyes were analyzed retrospectively. Each had at least two axial length (AL) measurements using immersion A-scan ultrasound in the second decade of life.

*Results:* Globe AL was 23.36 ± 1.52 mm at initial measurement and 23.89 ± 1.64 mm at last measurement. Measurement data show variable growth throughout the second decade of life. Based on our data, a theoretical patient was constructed with an AL at age 10 of 23.11 mm, who would need an IOL power of 21.5 for emmetropia. That same patient would have an AL of 23.76 mm (IOL power of 19.5) at age 15 and 24.41 mm (IOL power of 17.5) at age 20. That is a 4-diopter change in the IOL power need.

*Conclusion:* Axial eye growth continues throughout the second decade of life, at least to age 20. These data have important implications for the use of multifocal IOLs in the preteen and teenage years.

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## INTRODUCTION

The typical adult cataract patient is presbyopic and already accustomed to using bifocals or reading glasses when shifting from a distance visual task to a near visual task. In this patient population, monofocal intraocular lens (IOL) implantation can provide excellent return of visual acuity after cataract surgery. There is easy adaptation to bifocal lenses postoperatively, because the absence of accommodation was already present preoperatively. In contrast, the pediatric cataract patient enjoys a full range of accommodation preoperatively but none after surgery. For these patients, there is a built-in tradeoff, whereby improved clarity of vision is provided by surgery at the cost of the loss of accommodation. Adapting to the use of bifocals or reading glasses after surgery is not as easy as it is in the presbyopic adult.

For the adult patient seeking spectacle independence after cataract surgery, newer multifocal IOLs are gaining in popularity. Even if spectacles are used for some visual tasks, adults are often able to achieve spectacle independence for most distance, intermediate, and near tasks. For many of them, the optical tradeoffs of less contrast sensitivity and occasional glare and halos are acceptable to achieve relative freedom from the constant need for reading glasses.

There is now a growing interest in multifocal IOLs for younger patients, especially because at the time of cataract surgery, they lose accommodation in an eye that had very good preoperative accommodation.[1] One of the most important predictors of a patient's satisfaction after multifocal IOL implantation, at any age, is residual refractive error.[2] Satisfaction is highest for those with the least residual refractive error immediately after implantation and the greatest stability of that outcome over time. To achieve this, precise biometric measurements of globe axial length (AL) and corneal curvature are needed, followed by precise IOL power calculation using one of the modern formulas designed for this purpose. Emmetropia or slight residual hyperopia between +0.25 and +0.5 diopter (D) after multifocal IOL implantation has been suggested to avoid halos, preserving distance and near vision.[2] This can be applied to those subjects in whom refraction has stabilized and growth of the eye is complete.

In young children with growing eyes, the postoperative refraction is still undergoing a shift in the direction of myopia. However, as children approach adulthood, the growth of the eye slows down. Nearly 90% of the growth of the eye occurs in the first 2 years of life.[3] Therefore, some surgeons argue that growth in the second decade of life is sufficiently small that multifocal IOLs should be offered. The current study is designed to review axial growth of the eye in the second decade of life using our pediatric cataract patient population. These data could then be useful when discussing with patients and parents the decision to implant either a monofocal or a multifocal IOL after cataract surgery in the second decade of life.

## METHODS

This project received an exempt status from the Institutional Review Board of the Medical University of South Carolina. A retrospective search of our pediatric cataract database was performed. Eyes with at least two consecutive AL measurements (with first AL at or after 10 years of age) were included. Age at AL measurement and AL value were recorded. Ninety-eight eyes were analyzed retrospectively. In patients with unilateral cataract, axial growth of the operative eye was compared with that of the fellow noncataractous phakic eye.

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**Bold** type indicates AOS member.

## RESULTS

Mean age at initial measurement was 11.49 years, and mean age at last measurement was 15.21 years (Table 1). Globe AL mean was 23.36 ± 1.52 mm at initial measurement and 23.89 ± 1.64 mm at last measurement. Average axial growth was 0.53 mm (Table 1). Measurement data, displayed graphically, show variable growth throughout the second decade of life (Figure 1). Figure 2 illustrates longitudinal axial growth in the second decade of life. Some eyes grow more, and others grow less, but most eyes showed some growth in the second decade. This can also be seen in Figure 3. This histogram shows that 57.1% of eyes (56 of 98) grew from 0 to 0.5 mm, 37.8 % (37 of 98) grew from 0.5 mm to 1.5 mm, and 5.1% (5 of 98) grew more than 1.5 mm. Table 2 shows mean AL with increasing age in the second decade. This can also be seen in Figure 4. Based on these data, a theoretical patient was constructed with an AL at age 10 of 23.11 mm, who would need an IOL power of 21.5 for emmetropia. That same patient would have an AL of 23.76 mm (IOL power of 19.5) at age 15 and 24.41 mm (IOL power of 17.5) at age 20. That is a 4-diopter change in the IOL power need.

**TABLE 1. AXIAL LENGTH MEASUREMENTS IN 98 EYES OF PEDIATRIC CATARACT PATIENTS**

| VARIABLE | MEAN (±SD) | RANGE | MEDIAN |
|---|---|---|---|
| Age at initial measurement | 11.49 (±1.93) yr | 10.0 - 18.1 yr | 10.6 yr |
| AL at initial measurement | 23.36 (±1.52) mm | 20.02 - 27.73 mm | 23.37 mm |
| Age at last measurement | 15.21 (±2.88) yr | 11.0 - 24.36 yr | 15.02 yr |
| AL at last measurement | 23.89 (±1.64) mm | 20.51 - 28.95 mm | 23.71 mm |
| Axial growth | 0.53 (±0.52) mm | -0.24 - 2.08 mm | 0.35 mm |

AL, axial length.

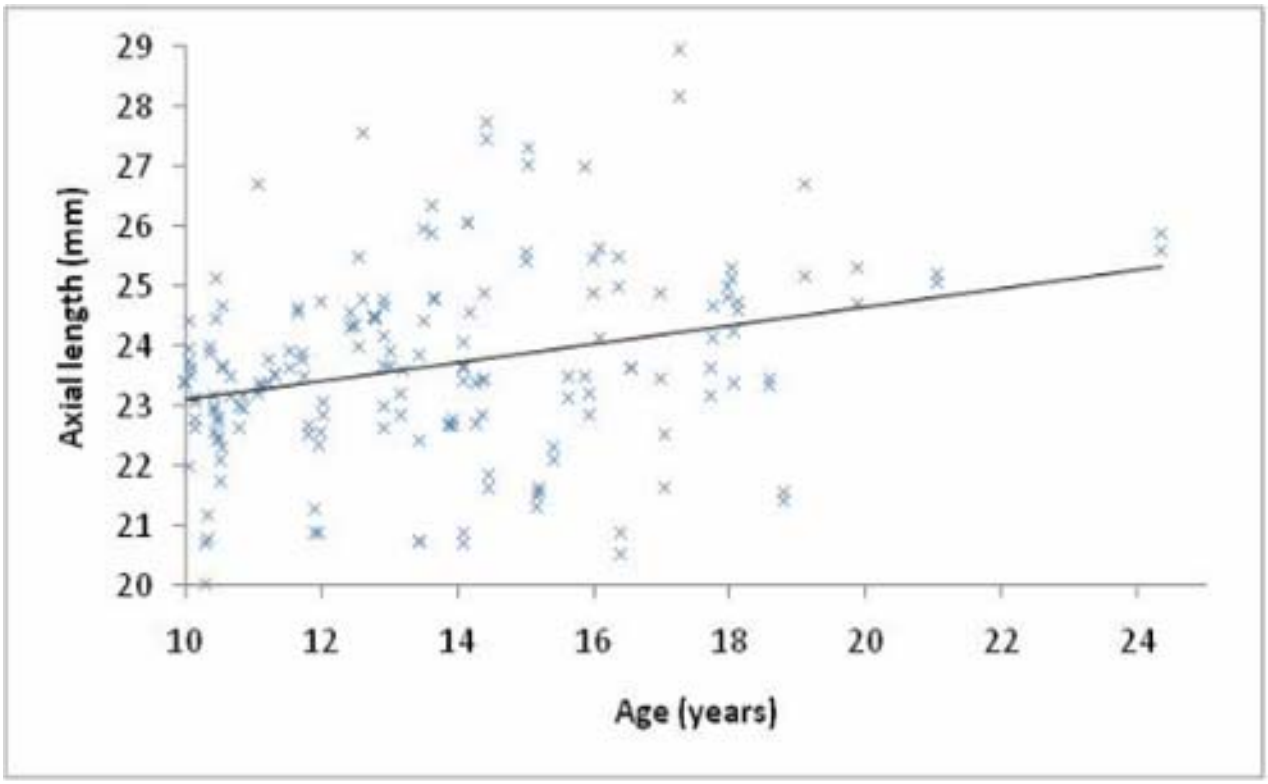


**FIGURE 1**

Scatter-plot showing axial length measurements according to age.

Axial growth of unilateral cataractous eyes after surgical removal of the cataract was significantly more than that of fellow eyes (median axial growth, 0.34 vs 0.23, $P$ = .03, Wilcoxon signed rank test). The range of growth (variability) was not significantly different between cataractous eyes and fellow eyes (SD, 0.53 vs 0.47).

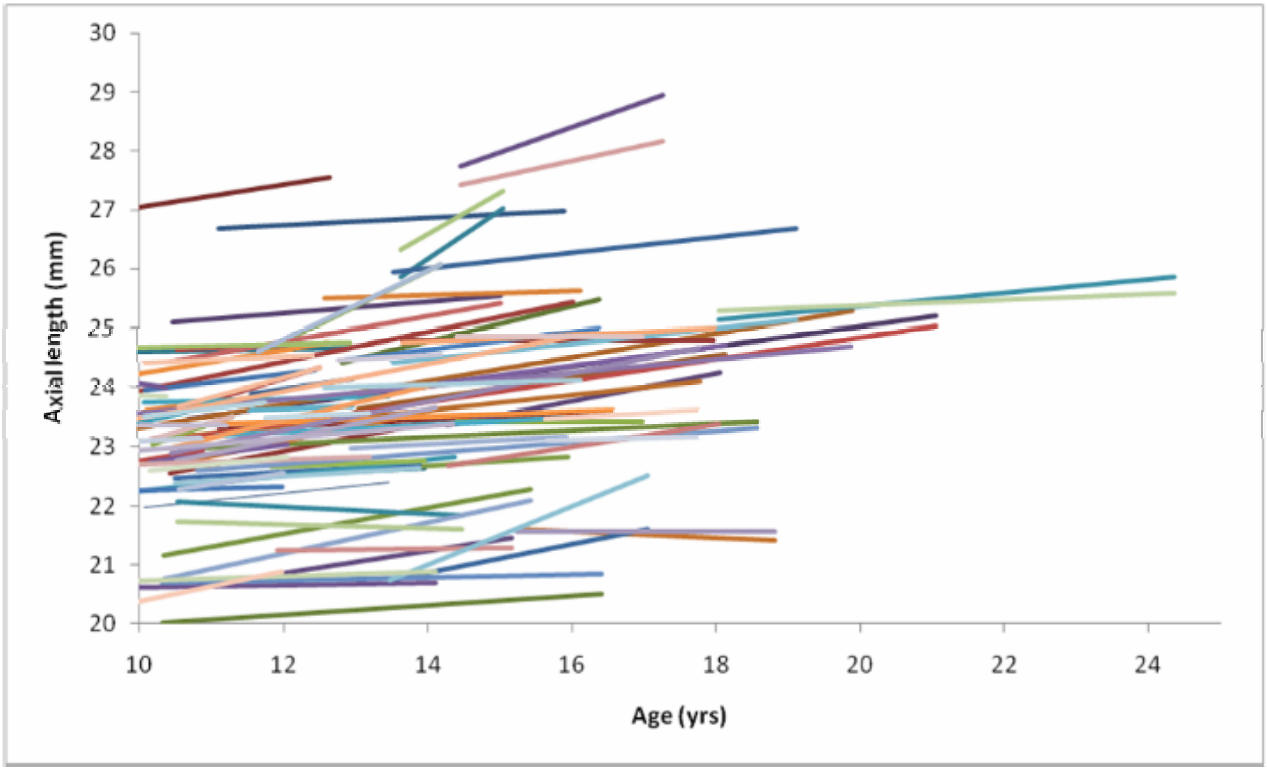


**FIGURE 2**

Longitudinal axial growth in the second decade of life.

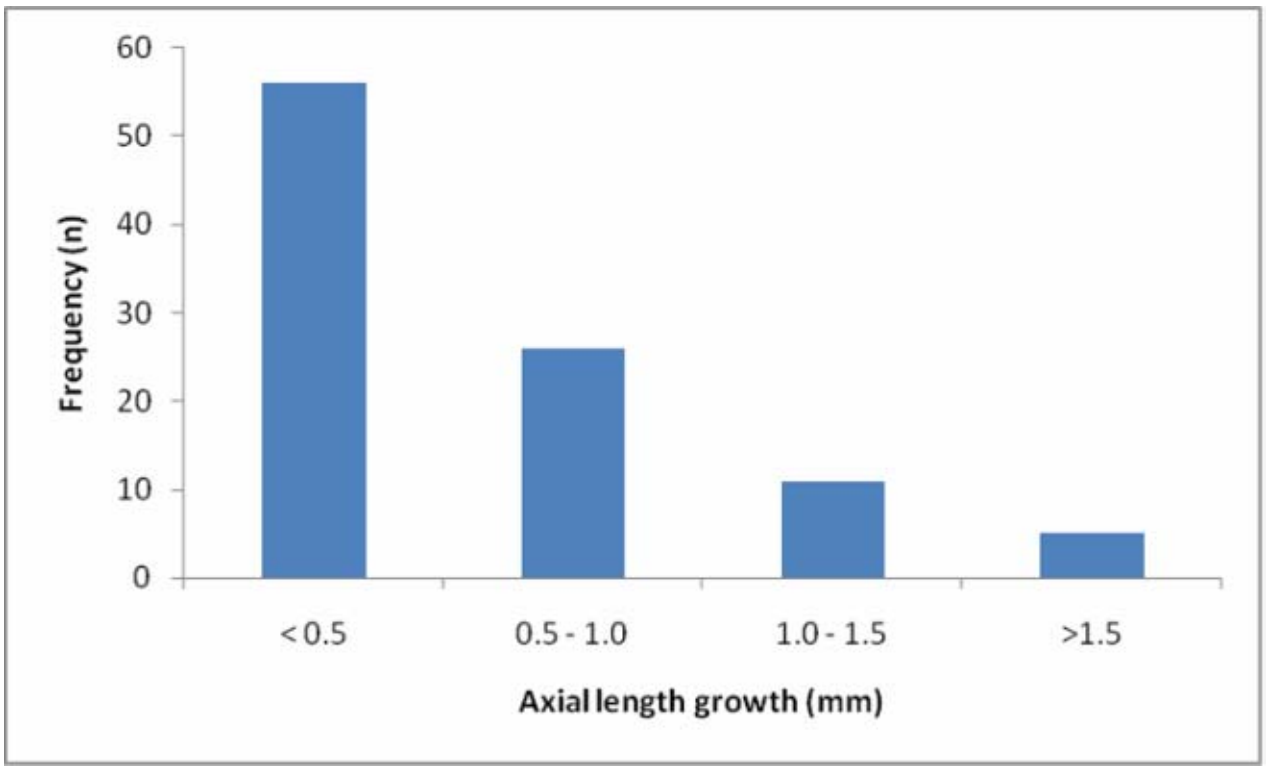


**FIGURE 3**

Frequency of axial length growth in four categories..

**TABLE 2. MEAN AXIAL LENGTH MEASUREMENT BY AGE CATEGORY IN 98 EYES OF PEDIATRIC CATARACT PATIENTS**

| AGE CATEGORY (yr) | AXIAL LENGTH (mm) mean (±SD) |
|---|---|
| 10 - 10.9 | 23.01 (1.24) |
| 11 - 12.9 | 23.74 (1.35) |
| 13 - 14.9 | 23.70 (1.66) |
| 15 - 17.9 | 23.97 (2.08) |
| 18 - 24.9 | 24.52 (1.32) |

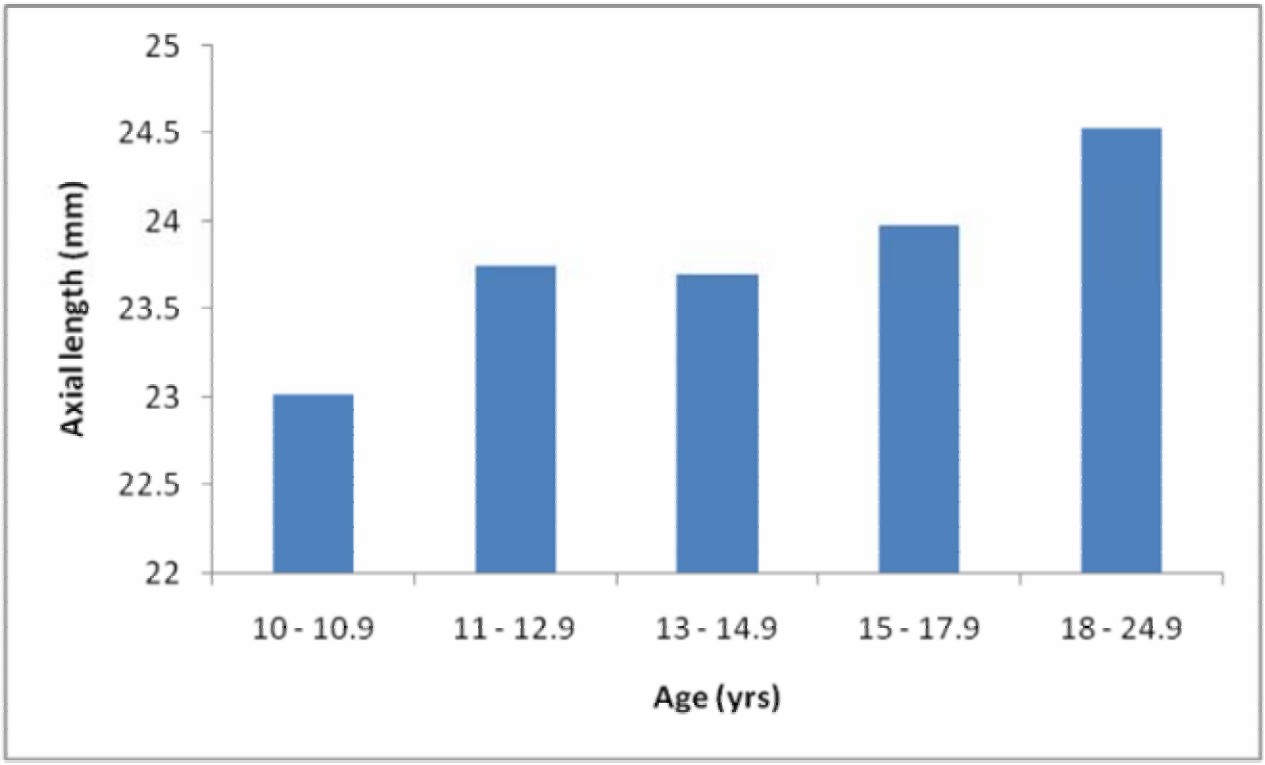


**FIGURE 4**

Mean axial length in different age categories.

## DISCUSSION

In our survey of American Association for Pediatric Ophthalmology and Strabismus (AAPOS) members, we asked, Would you consider implanting a multifocal IOL in children? The responses were as follows: yes (30.5%), not sure (37.6%), and no (31.9%).[1] However, many respondents commented (one question in the survey was open for comments) on their concern about the use of multifocal IOLs in children (related to refractive shift and the potential for degradation of amblyopia due to loss of contrast sensitivity). Some of the respondents also stated a reluctance to use multifocal IOLs in children until long-term follow-up of these IOLs is available. As this technology evolves, pediatric surgeons will actively debate the indications for multifocal IOL implantation in children.

Adult cataract and refractive surgeons, however, may be more enthusiastic about the use of multifocal IOLs in children in their second decade of life. This has been our opinion based on many discussions with surgeons at the annual meeting of the American Society of Cataract and Refractive Surgery (ASCRS) each year. Many assume that the growth remaining in an eye after the child reaches age 10 would be insignificant and would not interfere with the favorable outcome obtained with the implantation of a multifocal IOL. The AAPOS surgeons may be more conservative by nature, but as noted above, two-thirds of the respondents indicated a favorable or neutral position on the use of multifocal IOLs in children.

While the pros and cons of using multifocal IOLs in children are beyond the scope of this report, the consideration of the use of these implants has prompted us to analyze the axial growth we had documented in the second decade of life in our cataract database. In our experience, multifocal implant patients are less satisfied with their uncorrected vision when the eye grows and the refraction becomes myopic. In fact, ironically, the myopic patient with a multifocal IOL may actually be more spectacle-dependent than a patient with the same refraction who has a monofocal IOL implanted. Multiple images, none being focused on the retina, may prompt the patient to reach for glasses to correct the myopia more often than the mild to moderate myopic patient who has a monofocal IOL implanted.

The data reported herein show continued axial growth throughout the second decade of life. In addition, the variability of that growth is large. Therefore, predicting the exact amount of growth that will occur after IOL implantation is challenging, even in the second decade of life. With monofocal IOL implantation, mild to moderate myopia is common years after surgery. It is usually well tolerated. In fact, mild myopia has advantages for many of these patients, and they may elect to wear glasses only for sustained reading. Multifocal IOLs also have appeal for older children, since they have the potential to provide simultaneous distance and near focus. More than one teenager has remarked to us about how embarrassing it is to reach for reading glasses ("granny glasses") while on a date at a restaurant. Children and teenagers are also very adaptable and may not be bothered by glare and halos as much as some adults are. Our experience has borne this out.

At the very least, the data reported could be used during informed consent discussions with patients and parents so that expectations of the long-term need for spectacles can be realistic. Discussion can also include the possible need for laser refractive surgery to correct residual refractive error after growth has completed.

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Conformity With Author Information: This project received an exempt status from the Institutional Review Board of the Medical University of South Carolina.

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## PEER DISCUSSION

DR. EDWARD G. BUCKLEY: Wilson and co-authors provide some extremely important data about the continued growth of children's pseudophakic eyes well into the second decade of life. This is not surprising for those of us that have practiced pediatric ophthalmology for many years, but many cataract surgeons are seemingly unaware that this eye growth continues for so long. This is understandable since normally this would be of little consequence other than to require a glasses or contact lens power change as the child grows up.

Enter the new era of multifocal intraocular lenses (IOL) and now it becomes a huge issue. The concept that, if it is "good for grandma it is good for grandchild" needs to be approached with extreme caution in this instance. One look at Wilson's plot of refractive change over time among his cohort of patients should give any reasonable individual pause about suggesting a multifocal IOL in this age group. After watching my colleagues who are adult cataract surgeons sweat over a 0.25 diopter variance from calculated outcome in their patients receiving multifocal IOLs, dealing with the variability in this older child group would surely give them ulcers or drive them to excessive drink.

A comment in the manuscript that may not be fully appreciated, but anecdotally also has been my experience, is the range of acceptable visual function that can be achieved by standard monofocal intraocular lenses in this age group. Surprisingly, with a low myopic refractive error, they function quite well at both distance and near and often do not wear glasses for most, if not all, activities. The reason for this phenomenon is uncertain, but it clearly exists and it may be why many of us do not feel the need to complicate our patients' lives with this new unpredictable technology in this age group.

What I have found even more surprising is that some have suggested that these lenses be implanted in much younger patients to restore accommodation. What are they thinking? As Wilson clearly illustrates, the target refraction becomes so variable that the desired long term outcome is surely a random event and, even if achieved, a transient one. At a time when "evidence based medicine" is in vogue, clearly the evidence indicates that these lenses have no place in the treatment of aphakia in this age group.

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DR MALCOLM R. ING: No conflicts of interest. Ed, I had one question regarding patient satisfaction. Among adult patients with adult multifocal lenses, there has been a mixed reaction. Some patients do not like the visual acuity because they lack the sharpness of the image, and those that are able to tolerate the multifocal lenses are usually the cowboys who do not read very much. Have you studied the children who received multifocal intraocular lenses or have you implanted a sufficient number to know whether their acuity actually matches what we achieve with the conventional single vision intraocular lens with glasses?

DR. IRENE H. LUDWIG: No conflicts. All of those who take care of strabismus and amblyopia see a major influence of refractive development by strabismus and amblyopia. Did you correlate your refractive changes over the years with the level of both of the two situations?

DR. PENNY A.ASBELL: I thought this was an excellent paper. No conflict. I have two questions. First, was there some bias in subject selection in that you studied patients who had IOLs? It would be interesting to do either a case control report or comparison with normal patients who had no ocular surgery. Maybe you did this and perhaps I did not hear it. Secondly, did you take keratometry readings to determine if they changed during the second decade? Thank you.

DR. R. LAWRENCE TYCHSEN: To both Eds, Wilson and Buckley, I concede the excellent point that you both and others have made with regard to pediatric refractive surgery of any kind. We are shooting at a moving target. That is the basis for the dichotomous strategy that most of us use to determine which IOL power to implant in infants and toddlers. If we think a child will wear glasses, we make them several diopters hyperopic to produce a deliberate IOL under correction. The hyperopia is corrected with the glasses, betting that with increasing axial length over a period of years they will become emmetropic. On the other hand, if we think for behavioral or family-related reasons the child will not wear glasses reliably, we choose an IOL power that makes them emmetropic at surgery. During the critical amblyopiogenic toddler years they will benefit from quasi-emmetropia. They will become progressively very myopic with increasing axial length, and years down the road, we will need to do an IOL exchange.

Now conceding this point that we are shooting at a moving target with a monofocal IOL, what I have not heard articulated is the optical disadvantage of putting in a multifocal IOL. I do not consider the minimally-degraded contrast sensitivity of a multifocal IOL to be an important disadvantage. So I say, why not use a multifocal IOL and give the child a zone of 3½ diopters of optical "play"? What is the terrible disadvantage of that? We are using the same acrylic intraocular lens material lens and there has been no indication that pediatric biocompatibility is worse or that there is any other physical reason not to use one.

I use multifocal IOLs in many younger children. I never promise that they will be spectacle-free. I explain to the parents that like any other IOL, monofocal in particular, that we may need to do an IOL exchange at an older age. I explain to the parents that the rationale is to give the developing visual system more potential focal points for sharp vision. In young children, we are never going to achieve a postoperative ¼ diopter stable refractive target window, as is achievable in most adults implanted with a multifocal IOL, who expects to be spectacle-free. When we, as pediatric surgeons, use a multifocal IOL, our aim is different. We merely want to provide the growing child with a broader band of potentially clear, less amblyopiogenic vision, with or without glasses.

DR. M. EDWARD WILSON*:* Thank you for the discussion. I will thank Ed Buckley first. He is in agreement with me that the eyes continue to grow in the second decade of life. I believe that the opinion of multifocal intraocular lenses absolutely not being used in kids is a bit too strong. I agree that we have to be cautious in this regard and that it is mostly about expectations. We must make sure that we predict the future correctly for those individuals who chose to have that type of technology in the eyes.

To Malcolm Ing, I do implant multifocal IOLs in selected teenagers, but I do not have enough patients with multifocal intraocular lenses that I have implanted myself to tell you whether they like their vision better or worse. That would remain for others who have more experience to give you that impression. I certainly talk to a lot of adults, as a department chairman, who have been implanted with multifocal IOLs. I see a lot of our donors who have had these lenses placed in their eyes. I am always a little bit cautious hoping they are happy with their choice because their next gift might depend on it. However, for the most part they are very happy. Kids are very adaptable, so I am not too concerned about that part. However, when growth produces myopia in kids with multifocal IOLs, ironically they may be more dependent on their glasses than kids with monofocal IOLs.

Irene Ludwig asked about strabismus and amblyopia and whether these effect axial growth. I cannot give you a complete answer to that question, but we are in the process of studying it. I have a little more than a thousand eyes with serial axial lengths. I am in the habit of doing serial axial lens in kids and adults that I have implanted. We are looking at all of those factors. It is clear that amblyopic eyes grow more. We know that form-vision deprivation causes increased axial growth and many other factors affect it, as well.

Penny Asbell asked if we looked at growth in the normal eyes, and we have studied that. We have studied mostly the fellow eyes of monocular cataract implanted patients. The growth in the second decade of life certainly occurs in the fellow eyes that are normal and phakic and have not had implants. We have some data on normal growth and it continues. The keratometry readings we have determined and published. There is virtually no change in keratometry values in second decade of life.

Larry Tychsen discussed the balance of trying to prevent amblyopia and yet give them some refractive correction that would be good when they grow older. I agree with what he says. If we chose to use the multifocal implants or any other technology, then we must manage our expectations. Do not tell them they are going to be spectacle free. I have a number of patients, even back in the days of the first multifocal implants, such as the Array, where I concluded that they would not wear spectacles. I remember the first child

in whom I implanted a multifocal IOL. He was an adopted child from the Ukraine who did not understand English. He was just wild in the office and I chose to implant a multifocal IOL in both eyes. I left him hyperopic and I hoped that he would look through the near add in the multifocal for distance and then grow into the lens. Those patients, few as they were, have done well and have adapted. Then they have become myopic and, despite the multifocal IOL, they are spectacle dependent. We also have Lasik or IOL exchange or other options when they get older if they have become myopic. So, we are shooting at a moving target and I do not believe that we should exclude multifocal IOLs completely. We just need to be knowledgeable about that moving target. These lenses have some use. They may have some optical disadvantages, but they also have some optical advantages. As Larry said, they give us a range of focal points from which to choose. Thank you.