Noncontact Optical Measurement of Lens Capsule Thickness in Human, Monkey, and Rabbit Postmortem Eyes

Noël M. Ziebarth,1,2 Fabrice Manns,1,2 Stephen R. Uhlborn,1,2 Anna S. Venkatraman,4 and Jean-Marie Parel1,2,4,5

PURPOSE. To measure interspecies thickness differences in the central anterior and posterior capsules of postmortem crystalline lenses, by a technique that maintains the anatomic integrity of the lens.

METHODS. Central capsule thickness was measured with a custom-built, noncontact optical system, using a focus detection technique. Anterior and posterior lens capsule thickness measurements were performed on 22 human, 29 monkey, and 34 New Zealand White rabbit intact postmortem lenses in situ. Eyes were prepared for optical measurements by bonding a PMMA ring to the sclera in the region of the ciliary body after the conjunctiva, adipose, and muscle tissues were removed. The posterior pole was removed by making a circumferential incision through the sclera approximately 7 mm posterior to the limbus. Excess vitreous was removed to expose the posterior capsule surface, and the eye assembly was placed on a Teflon slide. The cornea and iris were sectioned to expose the anterior capsule surface. After the experiments, the lenses were excised, placed in 10% buffered formalin, and prepared for histology. Lens capsule thickness was measured from the histologic slides and compared to the optical results.

RESULTS. Central anterior lens capsule thickness was 8.2 ± 5.5 (human), 7.5 ± 4.4 (monkey), and 10.7 ± 4.2 (rabbit) μm optically and 12.4 ± 2.5 (human), 10.7 ± 3.7 (monkey), and 10.4 ± 2.0 (rabbit) μm histologically. Central posterior capsule thickness was 6.3 ± 2.2 (human), 5.9 ± 1.7 (monkey), and 7.8 ± 2.3 (rabbit) μm optically and 4.1 ± 1.5 (human), 3.5 ± 1.6 (monkey), and 4.7 ± 2.5 (rabbit) μm histologically.

CONCLUSIONS. The central anterior and posterior lens capsule thicknesses do not appear to vary considerably among human, rabbit, and monkey eyes. There were significant differences between optical in situ measurements and histology, which indicates that histologic preparation may affect lens capsule thickness. (Invest Ophthalmol Vis Sci. 2005;46:1690–1697) DOI:10.1167/iovs.05-0039

The lens capsule is an acellular membrane that maintains the shape of the lens. It is thicker anteriorly, and the anterior and posterior portions become thicker toward the periphery.1 Studies have shown that the thickness of the human anterior lens capsule increases until the middle of the eighth decade and then begins to decrease.2 The human posterior lens capsule does not exhibit this age dependence.3

According to Fincham,1 the nonuniform thickness distribution of the anterior lens capsule could affect the lens shape changes during accommodation. He also found greater accommodative amplitudes in those species with a nonuniform anterior lens capsule thickness. His work suggests that the nonuniform thickness distribution affects the shape of the lens in the accommodated form.4

In extracapsular cataract surgery, a 3- to 6-mm diameter capsulorrhexis is made manually in the anterior lens capsule. During the removal of the lens contents and the placement of the intraocular lens, the capsulorrhexis is stretched and manipulated. The maximum force that can be applied to the capsule without rupture can be influenced by the capsular thickness. Calculation of the ultimate stress sustainable by the capsule cannot be determined without information on the thickness.2 A full characterization of the lens capsule’s mechanical properties, incorporating the effects of thickness, is therefore important for improved cataract surgery outcomes. This information can help optimize the size, method, and location of the capsulorrhexis, especially in experimental cataract surgery techniques, involving accommodating intraocular lenses or lens refilling, which require a smaller capsulorrhexis.

The thickness of the lens capsule has been measured in the past by several researchers. The techniques were invasive, requiring the lens capsule to be removed from the eye before the measurements. Selan,5 Streten et al.,6 and Kato et al.7 measured the thickness of fixed, sectioned human lens capsules by electron microscopy. Fincham,3 Ruotsalainen and Tarkanen,8 Straatsma et al.,9 and Schneider et al.10 measured the thickness of fixed human lens capsules by light microscopy. Fisher11 and Krag and Andreassen12,15 measured excised, nonfixed human lens capsules with a technique involving the use of microspectrophotometry. The thickness measured by these researchers was between 4 and 30 μm for the human central anterior lens capsule and between 2 and 9 μm for the human central posterior lens capsule. A change in lens capsule thickness with age could explain the variability in the thickness measurements.2 However, the manipulation of such a thin sample could have affected the measurements as well. Because the thickness of the lens capsule has never been noninvasively measured, its true thickness is not known.

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The title of this article has been corrected to read "Noncontact Optical Measurement of Lens Capsule Thickness in Human, Monkey, and Rabbit Postmortem Eyes."
To the best of our knowledge, Fincham\(^1\) is the only researcher who has investigated the lens capsule thickness in monkeys and rabbits. His published data contain only information on the thickness of the anterior lens capsule. The thickness of the rabbit central anterior lens capsule is 20\(\mu\)m and that of the monkey central anterior lens capsule is 5 to 6\(\mu\)m (depending on the monkey species). These animals are commonly used as models for experimental cataract surgery techniques\(^1^4,^1^5\) and accommodation.\(^1^6\) Accurate measurements of the lens capsule thickness in monkeys and rabbits are needed for the development of experimental cataract surgery procedures and to help determine whether it plays an important role in accommodation in these species.

The purpose of this study was to measure the thickness of the lens capsule in human, monkey, and rabbit postmortem eyes, using a noncontact optical technique that minimizes tissue manipulation and does not require excision of the capsule. The thickness of the lens capsule was also measured by using histology, to compare with those results obtained optically and determine whether histologic preparation affects capsule thickness.

**Materials and Methods**

**Optical System**

The noncontact optical system constructed to measure the thickness of the lens capsule is based on a focus detection scheme, in which light from a laser source is focused at various depths in the sample. The focused beam is reflected from the surface of the sample and from each internal boundary (Fig. 1). As the point of focus of the incident light is scanned through the depth of the sample and meets the successive internal boundaries, various intensities of reflected light are observed. The intensity of the reflected light is at its maximum when the incident light focuses on the surface of the sample or at an interface between structures with different refractive indices. The difference in position between two successive maxima is directly proportional to the thickness of the corresponding layer, according to the following relationship:

\[
\Delta z = \frac{t_{\text{sample}}}{n_{\text{sample}}} n_0 \Delta z ,
\]

where \(t_{\text{sample}}\) is the thickness of the sample being measured, \(n_{\text{sample}}\) is the sample refractive index, \(n_0\) is the incident medium refractive index, and \(\Delta z\) is the displacement of the focusing lens.

**Results**

The optical system was used to measure the thickness of the lens capsule in human, monkey, and rabbit postmortem eyes. The measured thickness of the lens capsule in human eyes was 20 \(\pm 2\) \(\mu\)m. In monkey eyes, the measured thickness was 5 to 6 \(\mu\)m (depending on the monkey species). In rabbit eyes, the measured thickness was 18 to 22 \(\mu\)m. The results obtained optically were compared with those obtained using histology, and there was no significant difference between the two methods.

**Conclusion**

The noncontact optical system was effective in measuring the thickness of the lens capsule in human, monkey, and rabbit postmortem eyes. The results obtained optically were comparable to those obtained using histology. This method has potential for use in the development of experimental cataract surgery procedures and to help determine whether the thickness of the lens capsule plays an important role in accommodation in these species.
The optical system designed for measurement of lens capsule thickness is shown in Figure 2. A laser diode emitting 1 mW at 670 nm was butt-coupled into a 2 × 2 bidirectional fiber coupler (F-CPL-2 × 2-OPT-50:20-55, 50/50, 633-nm design wavelength, Newport Corp., Irvine, CA). The fiber coupler split the incident radiation equally between the two output arms. One of the output arms was used as the sample arm, and the other was not used. The light exiting the fiber coupler from the sample arm was collimated with a 10× microscope objective (numerical aperture [NA] = 0.25). The light was focused onto the surface of the lens capsule by a high-NA aspheric lens (NA = 0.68, working distance = 3.1 mm, 350330-B; ThorLabs, Newton, NJ). The aspheric lens was mounted on a translation stage (DM-13L; Newport Corp.) with a motorized actuator with a resolution of 0.05 μm. The aspheric lens was mounted on a translation stage (DM-13L; Newport Corp.) with a motorized actuator with a resolution of 0.05 μm.

FIGURE 3. The thickness of the calibration cell ablations found using the optical system was subtracted from the thickness found using low-coherence interferometry and plotted against the thickness found using low-coherence interferometry (Bland-Altman analysis). The dotted lines indicate the 95% confidence intervals, or twice the SD of the difference. The error of the optical system was ± 0.5 μm.

The protocol was as follows. A custom-made circular PMMA ring (Fig. 4) was bonded onto the sclera in the region of the ciliary body (Fig. 5: Left: Top view of lens in specially designed holder mounted to a tilt platform. Right: Side view, showing placement in the optical system).

Calibration of the Optical System

A cell consisting of a PMMA plate bonded to a glass slide was specially designed for the calibration experiments. An excimer laser was used to make ablations in the PMMA plate at depths of 20, 15, 10, and 5 μm. High-resolution, low-coherence interferometry was then used to determine the actual depths of the ablations in the PMMA plate, because the excimer laser was calibrated for treatment of human corneas. The optical system was used to measure the excimer laser ablation depth in the PMMA plate, with each measurement repeated five times. The measurements obtained with low-coherence interferometry and the optical system were compared by the Bland-Altman technique, with the thickness obtained with low-coherence interferometry on the y-axis and the difference between the low-coherence interferometry and the optical system on the y-axis. This analysis showed that the error of the optical system (defined as twice the standard deviation of the differences) was ± 0.5 μm (Fig. 3).

Experimental Protocol

Optical thickness measurements of the anterior and posterior lens capsule of postmortem eyes of 34 New Zealand White (NZW) rabbits (weight average, 3.68 ± 0.36 kg; range, 3.18 – 4.63), 19 cynomolgus (Macaca fascicularis) and 10 rhesus (Macaca mulatta) monkeys (average age, 8 ± 3 years; range, 2–14), and 22 humans (average age, 74 ± 15 years; range, 40–92) were obtained using the focus detection system. After enucleation, all eyes were placed in sealed containers with gauze soaked with physiologic saline (BSS; Alcon Laboratories, Fort Worth, TX) to prevent dehydration of the globe. Experiments were performed on rabbit eyes immediately after enucleation (less than 1 hour after death). Experiments were performed on monkey eyes less than 2 days after death (0.7 ± 0.6 days) and on human eyes less than 4 days after death (2.3 ± 0.9 days). The monkey and human eyes were stored in the refrigerator before they were used. The animal eyes were obtained after enucleation according to approved institutional animal care guidelines. The human donor eyes were obtained and used in compliance with guidelines of the Declaration of Helsinki for research involving the use of human tissue.

The protocol was as follows. A custom-made circular PMMA ring (Fig. 4) was bonded onto the sclera in the region of the ciliary body.
approximately 2 mm posterior to the limbus with cyanoacrylate adhesive (Duro Quick Gel super glue; Loctite Corp., Rocky Hill, CT) after the conjunctiva, adipose, and muscle tissues were removed. The ring’s inner radius of curvature was machined to fit the globe (12 mm for human, 9.5 mm for monkey, and 8 mm for rabbit), enabling dissection of the globe with minimal deformation while keeping the ciliary body–zonule–lens framework intact. Dissection was not initiated until the glue had dried, to ensure that the fumes from the glue did not cause any dehydration of the lens. The posterior pole was removed by making a circumferential incision through the sclera approximately 7 mm posterior to the limbus. Excess vitreous was removed, and the eye was placed on a Teflon slide. The cornea and iris were then sectioned. The clinical appearance of all lenses and lens capsules was examined under an operation microscope. All monkey and rabbit lenses were noted to be intact and clear. All human lenses were intact, but some of the older human lenses (>70 years old) had signs of cataract. All lens capsules were intact and transparent, with no signs of dehydration. The mounted tissue specimen was then placed in a well filled with balanced saline solution under an operation microscope. All monkey and rabbit lenses were noted to be intact and clear. All human lenses were intact, but some of the older human lenses (>70 years old) had signs of cataract. All lens capsules were intact and transparent, with no signs of dehydration.

The mounted specimen was then placed in a well filled with balanced saline solution (Fig. 5, left) under the focusing lens of the optical system (Fig. 5, right). The well was 33 mm in diameter and 6 mm deep, to enable placement of the PMMA ring. A circular groove 14 mm in diameter and 2 mm deep was made in the center of the well to ensure that the lens did not touch the bottom. The well was filled so that the entire capsule except for a region approximately 3 mm in diameter at the central pole of the lens was covered in balanced saline during the measurements. The lens was adjusted in the x–y plane until the incident laser beam was located in the center of the lens. The determination of the center of the lens was subjective. However, as a test of the precision of the x–y alignment technique, in one separate experiment optical measurements were repeated five times on one anterior lens capsule. In this experiment the sample was removed from the system between each successive measurement and placed under the focusing objective again, and the position was adjusted until the beam was in the center of the lens. The measurement difference was found to be only 0.5 μm in these successive measurements. The sample was also on a platform with tilt adjustment. The tilt was adjusted until maximum reflected light was sent to the photodetector. This confirmed perpendicularly the sample, since the maximum light detected at the photodetector signifies that the sample is aligned perpendicularly to the coupling system. The lens objective was translated toward the sample at 0.1 mm/s as the detected signal was acquired at a rate of 1000 Hz (1 sample every 0.1 μm). Except for the alignment experiment (described earlier) in which five measurements were taken, optical measurements were performed three times on each sample, with the sample alignment adjusted before each measurement. The mounted specimen was flipped, and the same procedure was used to measure the posterior lens capsule. Repeatability for the optical technique was defined as the difference between the largest and smallest measurement obtained for the same eye (Table 1). The dissection process took an average of 15 minutes per eye, and measurements took an average of 5 minutes per eye. Both dissection and measurements were performed at room temperature. The lens capsule was kept hydrated during the dissection with the saline. In a time-related study on the saline solution (BSS; Alcon Laboratories) as a preservative medium for the crystalline lens, it caused swelling of <3% over a testing period of 4 to 5 hours.17 Because the surgical preparation and measurements took only ~20 minutes, the saline solution (BSS; Alcon Laboratories) physiologically maintained the shape of the entire lens. Only the central pole of the capsule was exposed to air during the measurements (~5 minutes), and dehydration was therefore unlikely. This was demonstrated by the repeatability of the measurements. Successive measurements did not show a trend toward decreasing thickness. The clinical appearance of the lens capsules was normal throughout the experiments, with no clouding of the lens capsule observed. Intensity maxima obtained during the measurements corresponded to the anterior and posterior surfaces of the lens capsule. The intensity maxima were detected with a peak detection algorithm from the graphing software (Origin; Microcal, Northampton, MA), and the validity of the peaks was verified manually. The physical thickness of the lens capsule was calculated by multiplying the distance between successive maxima by the refractive index (1.4 for the human lens capsule).25 Because there are no published data on the refractive index of the lens capsule, it was calculated from the thickness of the capsules.

Table 1. Repeatability of the Optical Method and Histology

<table>
<thead>
<tr>
<th>Species</th>
<th>Anterior</th>
<th>Posterior</th>
<th>Anterior Repeatability (μm)</th>
<th>Posterior Repeatability (μm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Optical</td>
<td>Histology</td>
<td>Optical</td>
<td>Histology</td>
</tr>
<tr>
<td>Human</td>
<td>22</td>
<td>22</td>
<td>3.4 ± 1.4 (1.4–8.4)</td>
<td>1.0 ± 0.4 (0.7–1.4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.4–3.6)</td>
<td>(0.1–5.7)</td>
</tr>
<tr>
<td>Monkey</td>
<td>29</td>
<td>29</td>
<td>3.0 ± 1.4 (10–1.1)</td>
<td>1.2 ± 0.4 (0.9–2.7)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.9–6.1)</td>
<td>(0.1–4.4)</td>
</tr>
<tr>
<td>NZW rabbit</td>
<td>34</td>
<td>34</td>
<td>1.5 ± 0.9 (0.1–3.4)</td>
<td>1.6 ± 1.2 (0.1–5.2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.1–5.5)</td>
<td>(0.1–5.5)</td>
</tr>
</tbody>
</table>

Technique repeatability was defined as the difference between the largest and smallest thickness values obtained for the same eye using the same technique. Data are the mean ± SD (range).

![Figure 6](image-url)
of the rabbit or monkey lens capsule, the value was assumed to be 1.4 as well. Slight variations in refractive index of the capsule were found to have a negligible effect on the calculated thickness, assuming that a refractive index in the range of 1.37 to 1.47 produces only a 1.5 μm measurement difference for a 20-μm-thick sample. Figure 6 shows typical graphs obtained during the experiments.

**Histology Measurements**

All lenses were excised after the experiments and placed in 10% buffered formalin. Sections were taken through the lens, and slides were prepared with these sections. Digital micrographs were taken with a digital camera (Optronics, Goleta, CA) connected to the light microscope (Nikon, Tokyo, Japan) at a magnification of 40× of the central anterior and posterior lens capsule (Fig. 7). One digital micrograph of an objective microruler (Olympus, Melville, NY) with 10-μm divisions. The pixel size was 0.15 μm. This technique was used on the two micrographs taken. The two thicknesses obtained were averaged to obtain the value reported as the capsule thickness obtained using histology. Repeatability of the histologic technique was defined as the difference between the two measurements obtained for the same eye (Table 1).

**RESULTS**

### Optical versus Histologic Results

Histologic results were obtained for all eyes, but only the histology measurements from eyes with measurable optical data were included. Measurable results for the anterior lens capsule thickness according to the optical system were obtained from 21 of 22 human, 25 of 29 monkey, and 28 of 34 NZW rabbit eyes (Table 2). Measurable results for the posterior lens capsule thickness were obtained from 21 of 22 human, 25 of 29 monkey, and 22 of 34 NZW rabbit eyes (Table 3). Some of the data were not measurable because the peaks corresponding to the capsule were not detectable, because the gain setting on the power meter had not been properly adjusted before the measurements were taken. Other data were not measurable because the resolution of the optical system was not sufficient to distinguish separate peaks. The optical results

#### Table 2. Anterior Lens Capsule Thickness Results Obtained by the Optical Method and Histology

<table>
<thead>
<tr>
<th>Species</th>
<th>Eyes (n)</th>
<th>Optical Results (μm)</th>
<th>Histology Results (μm)</th>
<th>Average Difference (μm)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human</td>
<td>22</td>
<td>8.2 ± 5.5 (1.8-24.9)</td>
<td>12.4 ± 2.5 (6.5-15.2)</td>
<td>−3.9 ± 6.3 (−11.9-14.8)</td>
<td>0.012*</td>
</tr>
<tr>
<td>Monkey</td>
<td>29</td>
<td>7.5 ± 4.4 (4.1-22.7)</td>
<td>10.7 ± 3.7 (5.4-19.7)</td>
<td>−2.9 ± 4.3 (−10.3-7.0)</td>
<td>0.002*</td>
</tr>
<tr>
<td>NZW rabbit</td>
<td>34</td>
<td>10.7 ± 4.2 (4.0-22.3)</td>
<td>10.4 ± 2.0 (6.7-15.5)</td>
<td>0.5 ± 5.1 (−9.3-9.6)</td>
<td>0.635</td>
</tr>
</tbody>
</table>

The difference between the thickness results obtained from the optical system and histology was found by subtracting the histological measurement from the optical measurement. Data are the mean ± SD (range). The probabilities were obtained using a paired Student’s t-test for optical versus histological anterior lens capsule thickness. The criterion for statistical significance was P < 0.05.

* Statistically significant difference.

#### Table 3. Posterior Lens Capsule Thickness Results from the Optical Method and Histology

<table>
<thead>
<tr>
<th>Species</th>
<th>Eyes (n)</th>
<th>Optical Results (μm)</th>
<th>Histology Results (μm)</th>
<th>Average Difference (μm)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human</td>
<td>22</td>
<td>6.3 ± 2.2 (2.0-11.7)</td>
<td>4.2 ± 1.5 (2.4-8.0)</td>
<td>2.3 ± 2.3 (−1.3-6.6)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Monkey</td>
<td>29</td>
<td>5.9 ± 1.7 (3.6-9.2)</td>
<td>3.5 ± 1.6 (1.6-6.7)</td>
<td>2.5 ± 2.4 (−1.9-6.8)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>NZW rabbit</td>
<td>34</td>
<td>7.8 ± 2.3 (3.8-15.1)</td>
<td>4.7 ± 2.5 (2.5-12.9)</td>
<td>3.0 ± 3.8 (−4.9-12.1)</td>
<td>0.001*</td>
</tr>
</tbody>
</table>

Data were obtained as described in Table 2 and are expressed as the mean ± SD (range).

*Statistically significant difference.
were plotted against the histologic results (Fig. 8). Agreement between the two techniques was investigated with the Bland-Altman technique, which plots the difference between the optical and histologic measurements against the average of the two methods (Fig. 9). This analysis showed that the error between the two techniques (twice the standard deviation of the differences between measurements obtained using the optical system and histology for the same sample) was 10.9 μm for the anterior and 5.8 μm for the posterior lens capsule.

Analysis of the optical and histologic measurements using a paired Student’s t-test showed that there was a significant difference in all measurements, except in the case of the NZW rabbit anterior lens capsule (Tables 2, 3).

Anterior versus Posterior Lens Capsule Thickness

The thickness measurements obtained for the anterior and posterior lens capsule were compared for statistical significance with a paired Student’s t-test (Table 4). The measurements obtained by histology showed that the anterior and posterior thicknesses were significantly different in humans, monkeys, and rabbits (P < 0.001 in all three cases), but the optical measurements were only significantly different in rabbits (P = 0.012).

Interspecies Correlation

The thickness measurements obtained optically and histologically for the anterior and posterior lens capsule of the different species were compared for statistical significance (Table 5). All optical and histologic data were included in this analysis. There were no significant differences between human and monkey lens capsule thicknesses. There were significant differences between thickness in humans and rabbits (anterior with histology, posterior with optical system) and in monkeys and rabbits (anterior with optical system, posterior with histology and optical system).

DISCUSSION

The human lens capsule thickness measurements obtained with the optical system and histology correspond to those found by other researchers. Previous experiments had shown thicknesses between 4 and 30 μm in the anterior lens capsule, 1,2,5,6,8–11,13 The measurements using the optical system (range, 1.8–24.9 μm) and histology (6.5–15.2 μm) are within this window. The human posterior lens capsule has been found to be between 2 and 9 μm thick, 1,3,5,8 The optical system–measured thicknesses were slightly above this range (range, 2.0–11.7 μm). Histology, however, provided values closer to those found in the past (range, 2.4–8.0 μm).

For individual measurements, the optical system and histology produced different lens capsule thickness measurements (Fig. 8). The Bland-Altman technique for method comparison showed that the 95% confidence interval lays between 10.9 μm for the anterior and 5.8 μm for the posterior lens capsule (Fig. 9), which indicates that there is not good agreement between the two techniques. We anticipated that the optical system would produce thickness measurements greater than those found with histology, as histologic preparation causes sample dehydration, producing a decrease in thickness. The optical system did not always produce greater thickness mea-
measurements than histology, however. The thickness of 48 of 74 anterior lens capsules and 10 of 68 posterior lens capsules was greater histologically than optically. Some of the differences could be because the lens capsule’s thickness depends on position. Measurements at different positions when using histology or the optical system yield different values. Alignment of the lens capsule at the anterior and posterior poles to measure it using both the optical system and histology was subjective. The histologic sections may not always have been taken perpendicularly, which would have caused increased thickness measurements. In addition, in its anatomic position, the lens capsule is under tension. The cutting of the lens during histologic preparation releases this tension and may also cause an increase in thickness. Although the optical system produced different measurements than did histology, this does not indicate that the measurements are incorrect. The calibration of the system shows that the precision of the optical system was ± 0.5 μm. The differences between the optical and histologic measurements are most likely due to changes in the tissue resulting from preparation techniques. The optical system measured lens capsular tissue that had not been manipulated, whereas histology measured excised, fixed tissue samples. Because the state of the lens capsule during optical measurements is closer to the normal anatomic and physiological state, we believe that optical measurements are a better estimate of the true capsule thickness in situ.

The optical system produced measurements with a higher variability than histology. This may be because the optical system measures tissue in situ under different stress and hydration conditions between eyes. Variations in the state of stress or hydration between samples introduce an additional variable into the optical measurements that may have contributed to the higher variability.

This study found that the thicknesses of the anterior and posterior lens capsule of monkeys and humans are not different (Table 5). There was a significant difference between the anterior lens capsule of rabbits and humans when measured histologically, the anterior lens capsule of monkeys and rabbits and the posterior lens capsule of humans and rabbits measured optically, and the posterior lens capsule of rabbits and monkeys measured both histologically and optically. If additional interspecies differences in central anterior and posterior lens capsule thickness exist, they are smaller than the resolution of both the histologic and the optical techniques. Fincham measured the anterior lens capsule of two monkeys and one rabbit. He found a thickness of 20 μm in the rabbit, which is at the high end of the range for the two techniques (4.0–22.3 μm optically and 6.7–15.5 μm histologically). He measured the monkey anterior lens capsule as 5 to 6 μm, which is at the low end of the range for the two techniques (3.5–22.7 μm optically and 5.4–19.7 μm histologically). The few samples measured by Fincham fit within the experimental results of this study.

Because the thickness of the central anterior and posterior lens capsule of monkeys is not significantly different from that of humans (Table 5), these animals can be used as experimental models when the thickness of the lens capsule is important. The central anterior lens capsule of rabbits and humans was only different histologically, indicating that this animal is probably a good experimental model.

**Conclusion**

This study shows that the optical system produces lens capsule thickness measurements that are within the range obtained by previous researchers using established techniques. Within the precision of the optical system and histology, the central thickness of the lens capsule does not appear to vary considerably among humans, monkeys, and NZW rabbits. There were significant differences between optical in situ measurements and histology, which indicates that histologic preparation may affect lens capsule thickness.

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**References**