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In Vivo CT and MR Appearance of Prosthetic Intraocular Lens

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PURPOSE: **We present the first in vivo CT and MR imaging description of intraocular lenses (IOLs), which are commonly encountered in elderly patients who have undergone cataract surgery.**

METHODS: **A retrospective review was done of the imaging studies of 20 patients (22 eyes) with IOLs and of three patients (four eyes) with aphakia. CT and MR studies were performed with standard clinical protocols.**

RESULTS: **Sixteen patients with 18 posterior IOLs underwent six CT and 43 MR studies. Four patients with four anterior IOLs had one CT and eight MR studies. The exact position of the optic portion of the IOL could be optimally determined on CT scans with 1-mm-thick sections and on fat-saturated fast T2-weighted MR orbital coil studies performed on a 1.5-T imager. The haptics could not be distinguished from the ciliary body. Three patients with aphakia had eight MR and two CT studies. Aphakia was difficult to identify if the image thickness was greater than the diameter of the pupil (2.5 to 4.0 mm).**

CONCLUSION: **The optic portion of an IOL is visible on either high-quality CT or MR studies. However, the haptic portion is not visible on clinical in vivo images.**

Cataract is the number one cause of treatable blindness in the world (1, 2). In the United States, over 10% of the general population suffers from cataracts, with a prevalence rate as high as 95% in persons over 65 years of age (3, 4). Cataract extraction with implantation of an intraocular lens (IOLs) is the currently accepted treatment for most symptomatic cataracts. Over 2.6 million people undergo cataract surgery in the United States each year (4). Approximately 97% (3.8 million lenses) involve IOL implantation (1, 2, 4, 5). As a consequence, these devices are present in a significant proportion of orbital and brain images obtained in the elderly. Although the in vitro appearance of these devices has been reported (6), the in vivo radiologic appearance of IOLs has not been described. The purpose of this article is to describe the CT and MR imaging appearance of these devices.

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Methods

Clinical ophthalmologic records were reviewed retrospectively for the presence of aphakia or an IOL as determined by a neuroophthalmologist on slit-lamp examination. Those patients with an accompanying orbital or brain CT and/or MR examination were enrolled in the study. A high-speed helical scanner (General Electric) was used for the CT studies. Magnetom 0.5-T and 1.0-T imagers (Siemens) or a 1.5-T Signa (General Electric) unit was used for the MR studies. Table 1 describes the MR and CT parameters used for the patients studied. Only hard-copy axial images at the level of the lens and iris were reviewed. These imaging studies were then graded by a neuroradiologist and sorted into one of four categories: 1) only absence of the lens (aphakia) could be detected, 2) normal pupil anatomy (a centrally fenestrated line between the anterior and posterior chamber) was present, 3) a clearly defined optical lens component (optic) was seen in the pupillary opening (either anterior or posterior to the plane of the iris or crossing the pupillary opening), or 4) a partial volume artifact of the iris (a thin continuous line dividing the anterior and posterior chamber) was identified. Finally, the graded images were compared with the findings on slit-lamp examination for objective comparison.

Results

Twenty-three patients had nine CT studies (one brain and eight orbital) and 59 MR studies (43 brain and 16 orbital). A total of 68 imaging studies were reviewed. Patient information is summarized in Table 2. Findings at slit-lamp examination confirmed the presence or absence of an IOL (see Tables 3 and 4).

The greatest MR accuracy was achieved on the 1.5-T magnet with a 3-mm section thickness, a

TABLE 1A: MR imaging parameters

Scanner	0.5-T Magnetom (Siemens) 1.5-T Signa (General Electric)
Sequence	Fast spin-echo or spin-echo
TR/TE	TR range: 425–4000; TE range: 14–120
Field of view	Range: 12 × 12 cm to 26 × 26 cm
Section thickness	3–6 mm
Gap	0–7 mm
Matrix	Range: 192 × 256 to 512 × 256
Excitations	1 or 2
Scan type	Orbital* or brain†
Scan sequences	T1-weighted, T1-weighted with contrast; T1-weighted with fat saturation, T1-weighted with fat saturation and contrast, T2-weighted, fast T2-weighted, fast T2-weighted with fat saturation SDW‡

* A dual phased array 3-inch round surface coil (General Electric 3-inch circular coil model no. 46307144G1, Milwaukee, Wis) was used for all orbital MR sequences (n = 16) to produce better signal-to-noise ratio and to increase the resolution of the orbital anatomy.

† A head coil (Siemens Linear Head Coil, Iselin, NJ) was used for all 0.5T brain MR sequences (n = 43).

‡ SDW indicates spin density weighted.

TABLE 1B: CT parameters

Parameter	CT Values
Scanner	General Electric High Speed Advantage
Section thickness	1–5 mm
Scan type	Orbital or brain

0.5-mm gap, and a fast T2-weighted sequence with or without fat saturation. The poorest images were obtained on the 0.5-T magnet with thick sections and large gaps. The T1-weighted images were not optimal for visualizing IOLs. On CT scans, section thickness was the greatest predictor of image accuracy, with 1-mm-thick sections providing the best results.

Discussion

The native human lens is readily seen on clinical MR images and CT scans as an ovoid mass suspended behind the plane of the iris with a relatively flattened anterior surface and a convex posterior surface. On a T1-weighted image with and without contrast enhancement, the native lens appears slightly hyperin-

TABLE 4: Comparison of CT and MR findings in three patients who had both CT and MR examinations

Slit-Lamp Examination	CT Findings	MR 1.5 T (T2- and T1-Weighted Studies)
Aphakia		
Patient 1	Only absence of lens detected	Centrally fenestrated line (normal pupil anatomy)
Patient 2	Continuous thin line (partial volume artifact)	Continuous thin line (partial volume artifact of iris)
Posterior IOL		
Patient 3	Only presence of optic detected	Only presence of optic detected

TABLE 2: Summary of imaging studies

Slit-Lamp Findings	No. of Patients	No. of Eyes	Imaging Studies (CT + MR)	MR	CT
Aphakia	3	4	10	8 orbital studies (on 1.5-T imager)	2 orbital studies
Posterior IOL	16	18	49	40 brain studies (2 on 1.5-T and 38 on 0.5-T imager) 3 orbital studies (on 1.5-T imager)	5 orbital studies 1 brain study
Anterior IOL	4	4	9	5 orbital studies (on 1.5-T imager) 3 brain studies (on 0.5-T imager)	1 orbital study

Note.—IOL indicates intraocular lens.

TABLE 3: Comparison between slit-lamp findings and imaging findings (number of eyes with the described imaging pattern/number of eyes in the group)

Slit-Lamp Examination	CT	MR at 1.5 T (T1- and T2-Weighted Studies)	MR at 0.5 T (T2- and T1-Weighted Studies)
Aphakia	Continuous thin line (1/2) (partial volume of iris) Only absence of lens (1/2)	Centrally fenestrated thin line (5/8) (normal pupil anatomy) Continuous thin line (1/8) (partial volume of iris) Interpretation complicated by silicon oil tamponade (2/8)	. . .
Posterior IOL	Optic posterior to plane of iris (1/6) Only presence of optic detected (5/6)	Only presence of optic detected (3/5) Continuous thin line (1/5) (probably partial volume artifact of iris) Only absence of lens, no optic detected, (1/5)	Optic posterior to plane of iris (0/38) Only presence of optic detected (18/38) Only absence of lens detected (17/38) Continuous thin line (3/38) (probably partial volume of iris)
Anterior IOL	Optic anterior to plane of iris (1/1)	Optic anterior to plane of iris (5/5)	Only absence of lens, no optic detected (3/3)

Note.—IOL indicates intraocular lens.

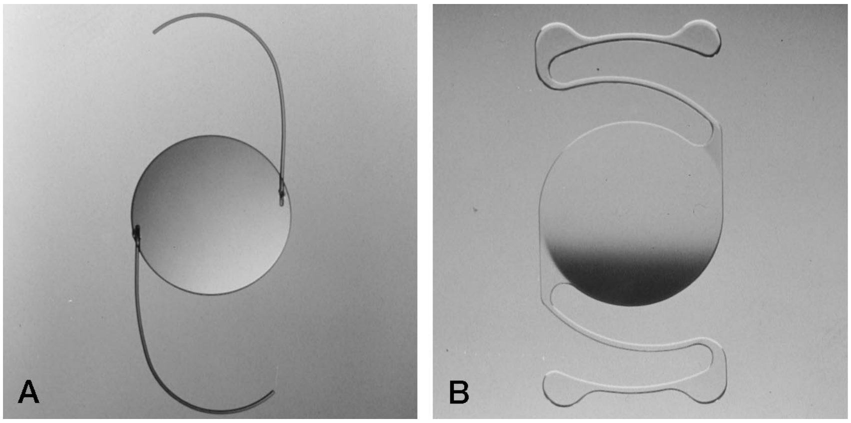


FIG 1. Posterior (*A*) and anterior (*B*) IOLs are composed of a central optic portion and two haptics that hold the device in place. (Photographs provided courtesy of Chiron Vision, Claremont, Calif).

tense relative to the hypointense surrounding aqueous humor anteriorly and vitreous posteriorly. However, the native lens is seen best on a T2-weighted image, on which it appears as a markedly hypointense oval mass with respect to the hyperintense vitreous and aqueous. Aphakia, absence of the lens, is not readily appreciated on MR and CT studies unless they include this region in the field of view.

Before one can recognize the imaging appearance of IOLs, it is necessary to understand the structure and composition of these prosthetic devices. Because they are relatively impermeable, IOLs do not enhance. Fundamentally, all IOLs consist of two components: an optical lens component, called the optic, and footplates, called haptics, that are used to maintain the optic in position (Fig 1). Although a great variety of styles exist, current optic sizes range from 5- to 7-mm in diameter. Haptic sizes range from 12- to 14-mm in length (1, 3). Prior to the mid-1980s, haptics were made of platinum, which would be expected to produce a signal void on all pulse sequences. Current materials used in the construction of IOLs include polymethylmethacrylate (PMMA), polypropylene (Prolene), silicone, a 38% water-content polyhydroxyethyl-methacrylate (hydrogel), and polyethylene (Dacron) (7). The majority of IOLs are manufactured with PMMA and Prolene. Most rigid IOL optics are made from PMMA, and the haptics from either PMMA or Prolene, whereas flexible IOLs are made from either silicone or polyhydroxyethylmethacrylate (PHEMA) (8).

Absence of the lens (aphakia) can mimic an IOL if the axial sections contain portions of the iris above and below the level of the pupil, allowing the partial volume artifact to obscure the pupillary opening (Figs 2 and 3). Owing to its structural composition, the IOL produces a dark signal void on T1-weighted images and thus is difficult to distinguish from the low signal regions that surround it. For this same reason, an IOL is best appreciated when it is surrounded by bright areas on T2-weighted images with or without fat saturation.

IOLs can be subdivided by the position they occupy within the eye. Implants in the posterior chamber of the eye account for over 90% of all IOLs currently used in the United States (1, 3, 8–10) (Fig 1A). The

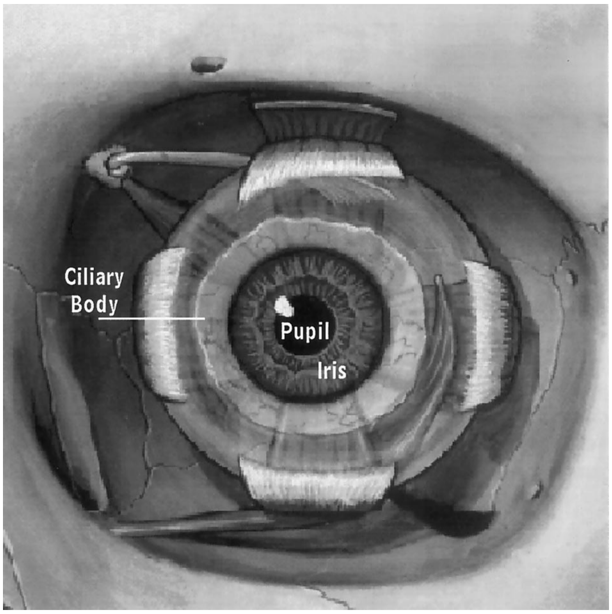


FIG 2. Coronal view of the eye shows the normal pupil opening of 2.5 to 4 mm. An axial image that is thicker than the pupil or that does not center precisely on this opening will contain parts of the iris above or below the pupil opening. This causes a partial volume artifact, which is a significant problem in patients with small pupils (ie, the elderly). (Photograph modified with permission from [11]).

optic and haptics in these IOLs are located behind the iris and are supported by the residual capsule of the lens or by haptics positioned in the ciliary sulcus, just anterior to the ciliary process (1, 3, 7, 8) (Fig 4). The haptic loops maintain the position of the IOL and prevent the lens from dislocating. They are eventually encased by a fibrous shell (1, 3). These IOLs most closely resemble the position of the native lens (1, 3, 7). They usually can be seen posterior to the plane of the iris but they can appear as a continuous thin line between the anterior and posterior chambers of the eye. The latter appearance is identical to the partial volume iris artifact seen in patients with aphakia.

Since the advent of posterior chamber IOLs, anterior chamber IOLs are seen less commonly. They constitute less than 10% of all IOLs currently placed in the United States (Fig 1B) (10). Today, they are

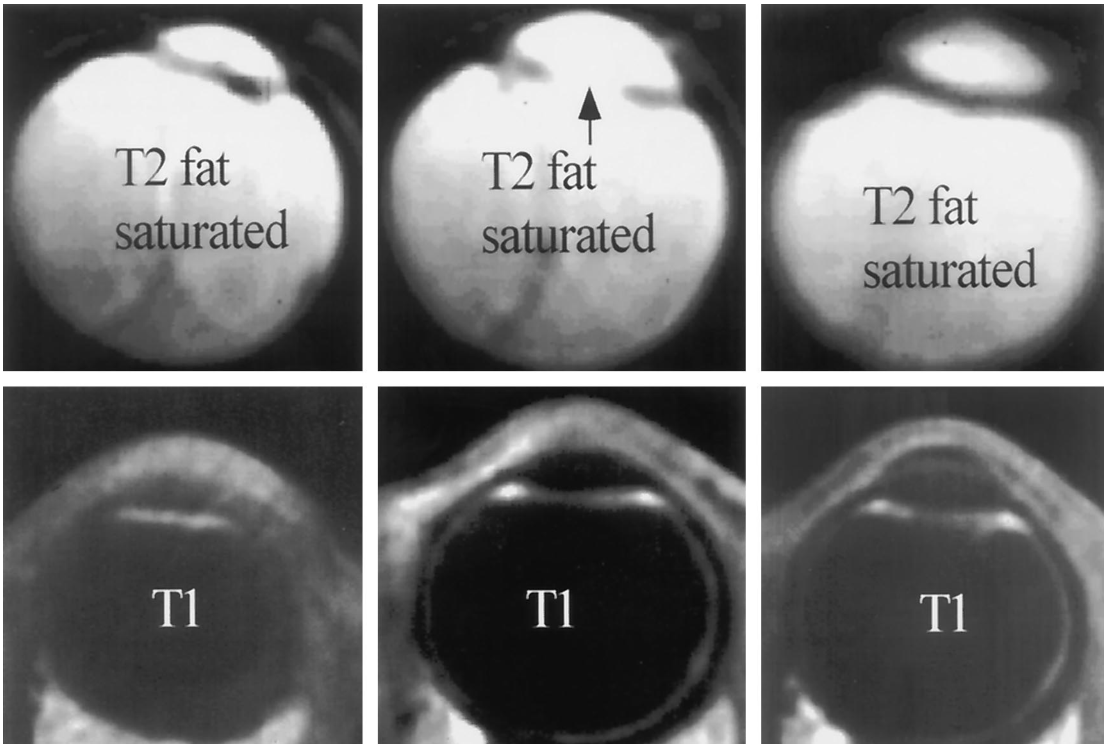
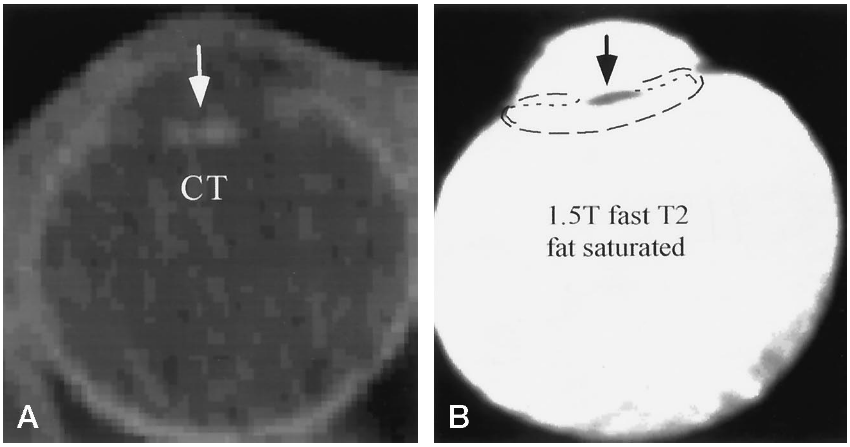


FIG 3. Serial axial images in aphakia (no IOL) show the pupillary opening (*arrow*) in the fast T2-weighted fat-saturated images (*top row*). Companion serial T1-weighted images (500/15) (*bottom row*) show a partial volume artifact (see Fig 2), which obscures the pupillary opening. On the T2-weighted fat-saturated images, the bright signal in the anterior globe, as compared with the posterior globe, occurs as a result of loss of signal as the tissue becomes farther removed from the surface of the coil.

FIG 4. Axial images through iris show a posterior IOL (*arrow*) on companion CT scan (*A*) and fast T2-weighted fat-saturated MR image (4000/102) (*B*). *Dotted lines* on the MR image indicate the position of the unseen haptics, and *dashed lines* show the invisible lens capsule. Note that the latter has been opened anteriorly to remove the native lens and allow the insertion of the IOL.



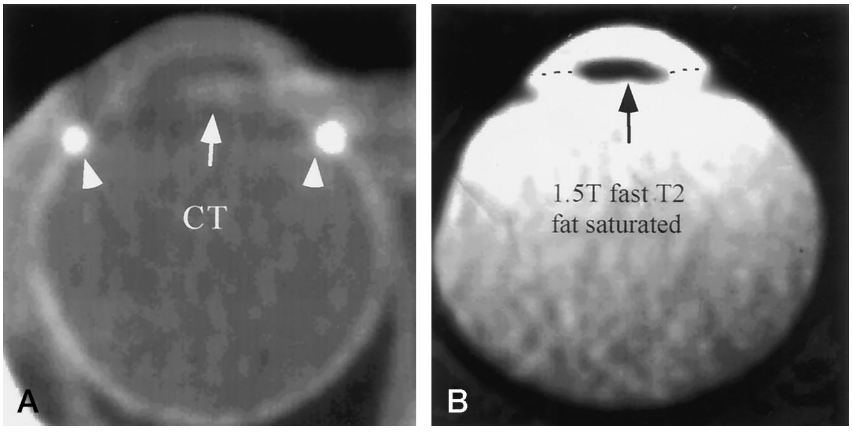


FIG 5. Axial images through iris show an anterior IOL (*arrow*) on companion CT scan (*A*) and fast T2-weighted fat-saturated image (4000/102) (*B*). *Dotted lines* on the MR image indicate the position of the unseen haptics, which extend into the angle formed by the iris (posteriorly) and the cornea (anteriorly). The lens capsule has been surgically removed. The silicone band (*arrowheads*) seen on the CT scan is not visible on the MR image owing to a lack of contrast between its signal void and the hypointense area at its outer margins. On the fast T2-weighted fat-saturated images, the brighter signal in the anterior globe relative to the posterior globe occurs as a result of loss of signal as the tissue becomes farther removed from the surface of the coil.

used primarily in patients with previous damage to the posterior capsule or as an alternative choice if the posterior capsule is accidentally ruptured during cataract surgery (8). Anterior chamber IOLs are positioned entirely in the anterior chamber, with the optic supported by haptics wedged in the anterior chamber angle. On imaging, they appear slightly anterior to the plane of the iris (Fig 5).

Conclusion

The presence and position of an IOL can be routinely determined in vivo on orbital images obtained on a high-resolution scanner with thin sections (1 mm for CT and 3 mm for MR imaging) centered on the pupil. In our study of imaging examinations obtained at routine settings for orbital or brain anatomy, fast T2-weighted images with or without fat saturation showed the IOL to best advantage.

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