ARTICLE

Clinical and histopathological findings in the dead bag syndrome

Catherine Culp, MD, Phillip Qu, MD, Jason Jones, MD, Nicole Fram, MD, Gregory Ogawa, MD, Samuel Masket, MD, Nick Mamalis, MD, Liliana Werner, MD, PhD

Purpose: To describe the findings of a recently described syndrome, the dead bag syndrome, in which the capsular bag appears to be clear many years postoperatively, becoming diaphanous and floppy and unable to support the intraocular lens (IOL) within it.

Setting: John A. Moran Eye Center, University of Utah, Salt Lake City, Utah.

Design: Case series with clinicopathological correlation.

Methods: Of 10 cases suspected to represent a dead bag syndrome, 8 IOLs and 7 capsular bags were removed because of subluxation or dislocation. The 7 capsular bags available for analysis were fixed in formalin and submitted to histopathological examination (hematoxylin–eosin and Masson trichrome stains). The associated explanted IOLs in 5 cases were also examined microscopically.

Results: Histopathologic examination of the 7 capsular bags showed capsular thinning and/or splitting. Lens epithelial cells (LECs) were completely absent on 2 specimens, whereas the other 5 specimens had rare LECs on the inner surface of the capsule. Explanted IOLs were 3-piece silicone IOLs or single-piece hydrophobic acrylic IOLs. 1 IOL optic showed a small amount of granular pigment deposition, but the optics of the other 4 IOLs were unremarkable.

Conclusions: In this syndrome, there seems to be an absence of secondary proliferation of LECs and fibrotic changes. The capsule shows some signs of degradation, such as thinning and/or splitting. Weakness of zonular attachments seems to be an associated finding, with subsequent in-the-bag IOL dislocation. Further studies are necessary to ascertain the etiology of this condition.

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Intraocular lens (IOL) subluxation or dislocation is a serious complication of cataract surgery, being usually described as occurring at various postoperative times. Early IOL dislocation mostly occurs in association with inadequate IOL fixation; its rate has decreased since the advent of continuous curvilinear capsulorhexis. Late in-the-bag spontaneous IOL dislocation, occurring more than 3 months postoperatively, generally results from zonular weakness. This complication is also frequently associated with previous pars plana vitrectomy.[1–4]

One of the most important conditions leading to zonular weakness and, subsequently, IOL dislocation is pseudoexfoliation.[4,5] It has been suggested that pseudoexfoliation might be implicated in an even larger proportion of late in-the-bag IOL dislocations than previously believed to be because of significant clinical underdiagnosis. In a series analyzing 40 late in-the-bag IOL dislocation cases, 26 specimens represented by capsular bags containing an IOL or an IOL and a capsular tension ring had histopathological evidence of pseudoexfoliation material.[6] Lens epithelial cells (LECs) and Soemmerring's ring formation were present within the capsular bag in all cases. Fibrous metaplasia of anterior LECs, with capsular contraction and sometimes capsular phimosis, was also a common finding.

In the past couple of years, there have been anecdotal reports of late postoperative IOL dislocation either through defects in the periphery of the bag or in-the-bag dislocation sharing the common feature of a very clear bag many years postoperatively, without fibrotic changes or proliferative material within it. The capsular bag in those cases had apparently become diaphanous and floppy and was unable to support the IOL within it. One of us (S.M.) has coined the term dead bag syndrome referring to such cases, which have been the subject of discussions in the EyeConnect Listserv of the ASCRS. In this study, we aimed to describe the clinical features of such cases and histopathological findings from the cases with capsular bag specimens

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From the Department of Ophthalmology and Visual Sciences, John A. Moran Eye Center, University of Utah, Salt Lake City, Utah (Culp, Qu, Mamalis, Werner); Jones Eye Clinic, Sioux City, Iowa (Jones); Advanced Vision Care, Los Angeles, California (Fram, Masket); Eye Associates of New Mexico, Albuquerque, New Mexico (Ogawa).

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Corresponding author: Liliana Werner, MD, PhD, John A. Moran Eye Center, University of Utah, 65 Mario Capecchi Drive, Salt Lake City, UT 84132. Email: liliana.werner@hsc.utah.edu.

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Table 1. Dead Bag Syndrome Case Characteristics.

Demographic	Case 1	Case 2	Case 3	Case 4	Case 5
Explanting surgeon	J.J.	N.F.	J.J.	J.J.	J.J.
Age at explantation, y	72	70	66	68	62
Sex	M	F	M	M	M
Race/ethnicity	Non-Hispanic Caucasian	Non-Hispanic Caucasian	Non-Hispanic Caucasian	Non-Hispanic Caucasian	Non-Hispanic Caucasian
Eye	Left	Right	Left	Left	Left
Associated ocular conditions	Proliferative DR, ERM, PCO, ocular migraine, anterior basement membrane dystrophy, PVD, pan-retinal photocoagulation, small corneal scar	None	Dermatochalasis, ERM, dot and blot hemorrhage, PVD, pinguecula	Dermatochalasis and RD treated with laser	Myopia and history of bilateral retinal tears treated with barrier laser in both eyes
Associated general conditions	Hypothyroidism, type 1 diabetes, hypertension, hyperlipidemia, diabetic nephropathy, history of kidney and pancreas transplantation	Type 2 diabetes, depression, hypertension, GERD hyperlipidemia	Hypothyroidism, type 2 diabetes, hypertension, diabetic nephropathy, COPD, kidney disease, cancer (unspecified type)	Hypertension, RHD, OSA, prediabetes	GERD, cirrhosis
IOL type	SI30, 3-piece silicone, Prolene haptics (Abbott Medical Optics, Inc.)	TECNIS, 1-piece hydrophobic acrylic, haptics (Johnson & Johnson Vision)	SI30, 3-piece silicone, Prolene haptics (Abbott Medical Optics, Inc.)	SI30, 3-piece silicone, Prolene haptics (Abbott Medical Optics, Inc.)	TECNIS, 1-piece hydrophobic acrylic, haptics (Johnson & Johnson Vision)
Length of implantation (y)	13.75	7.8	16.5	18.8	4
Explantation reason	In-the-bag IOL dislocation	Inferior in-the-bag IOL subluxation, then in-the-bag IOL dislocation into the AC	IOL subluxation	In-the-bag IOL dislocation	In-the-bag IOL dislocation
Explantation/ exchange procedure (summary of available information)	Anterior vitrectomy, vitreal staining with triamcinolone, optic bisected and IOL removed, remaining capsule removed, scleral fixation using Yamane technique, and PI ×2	Scleral fixation using Yamane technique	IOL had migrated through a defect in the posterior capsule and was laying on the anterior hyaloid; anterior vitrectomy, vitreal staining with triamcinolone, optic bisected and IOL removed, remaining capsule removed, scleral fixation using the Yamane technique, and PI ×2	Anterior vitrectomy, vitreal staining with triamcinolone, optic bisected and IOL removed, remaining capsule removed, and scleral fixation using the Yamane technique	Anterior vitrectomy, vitreal staining with triamcinolone, optic bisected and IOL removed, remaining capsule removed, scleral fixation using the Yamane technique, and PI ×2
Exchange IOL type	CT Lucia, 3-piece hydrophobic acrylic, PVDF haptics (Carl Zeiss Meditec AG)	EC-3 PAL, 3-piece hydrophobic acrylic, PVDF haptics (Aaren Scientific, Inc.)	CT Lucia, 3-piece hydrophobic acrylic, PVDF haptics (Carl Zeiss Meditec AG)	CT Lucia, 3-piece hydrophobic acrylic, PVDF haptics (Carl Zeiss Meditec AG)	CT Lucia, 3-piece hydrophobic acrylic, PVDF haptics (Carl Zeiss Meditec AG)
Results after explantation/ exchange (postop follow-up)	IOL well positioned. UDVA 20/30-2; CDVA 20/20-2; IOP 16 mm Hg; PI at 11 and 1 o'clock (13.5 mo)	IOL well positioned (32 mo)	IOL in slightly temporal position; UDVA 20/20; IOP 18 mm Hg; PI at 10 and 12:30 o'clock; peripheral transillumination defect at 6 and from 7:30 to 8:30 o'clock (28 d)	IOL well positioned; UDVA 20/30+2; CDVA 20/20; IOP 14 mm Hg (15 d)	IOL well positioned; UDVA 20/20; IOP 12 mm Hg; PI at 10 and 12 o'clock; midperipheral transillumination defect; iridodonesis (6 wk)

(continued on next page)

Table 1. Continued

Demographic	Case 6	Case 7	Case 8	Case 9	Case 10
Explanting surgeon	N.F.	G.O.	S.M.	S.M.	G.O.
Age at explantation, y	56	60	57[a]	38[a]	75
Gender	M	F	M	F	M
Race/Ethnicity	Asian	Non-Hispanic Caucasian	Asian	Non-Hispanic Caucasian	Non-Hispanic Caucasian
Eye	Left	Left	Left	Right	Right
Associated ocular conditions	History of RD repair with endolaser, PPV, membrane peel	LASIK for myopic astigmatism in both eyes	None	Intumescent white cataract	None
Associated general conditions	None	Minor surgeries	None	None	Knee replacement, arthritis, liver cancer
IOL type	TECNIS, 1-piece hydrophobic acrylic, haptics (Johnson & Johnson Vision)	SN60WF AcrySof, 1-piece hydrophobic acrylic, haptics (Alcon)	CQ2015A, 3-piece IOL, polyimide haptics (STAAR Surgical)	SN60WF AcrySof, 1-piece hydrophobic acrylic, haptics (Alcon)	SN60AT AcrySof, 1-piece hydrophobic acrylic, haptics (Alcon)
Length of implantation (y)	3.7	8	NA	NA	12.3
Explantation reason	In-the-bag IOL dislocation, 3 mo after Nd:YAG laser posterior capsulotomy	Nasal subluxation of IOL still in the bag through peripheral capsular defect. 1 haptic still in the bag; focal area of fibrosis in relation to its tip; remaining capsular bag was very clear. Other haptic and part of optic was out of the bag through peripheral defect	NA	NA	Inferior dislocation of IOL into vitreous cavity through peripheral/ posterior capsular defect, with IOL positioned just posterior to the remaining posterior capsule.
Explantation/ exchange procedure (summary of available information)	Anterior vitrectomy and scleral suture fixation with PTFE suture	IOL brought anteriorly and explanted. Capsular bag too tenuous for long-term IOL fixation; removed with 25-gauge forceps. Removal of bag easy as the ZF detached from bag. Single-port PPV performed. Scleral fixation of new IOL with PTFE suture. Superior PI ×2	NA	NA	IOL haptic brought anteriorly enough to use CTC-6L needle for clothesline support while performing single-port PPV to remove vitreous and blood from around IOL. IOL brought into AC, refolded, and removed. Sulcus fixation of new IOL with posterior optic capture
Exchange IOL type	MX60E, 1-piece hydrophobic acrylic, haptics (Bausch & Lomb, Inc.)	CZ70BD, 1-piece PMMA (Alcon)	NA	NA	MA60AC, 3-piece hydrophobic acrylic (Alcon)
Results after explantation/ exchange (postop follow-up)	IOL well positioned; PRK for refractive error (15 wk)	IOL well positioned; residual vitreous heme from scleral incisions (1 wk)	Capsular bag completely clear. Unremarkable until 46 mo. Nasal zonulysis with vitreous noted in AC at 70 mo	No anterior or posterior capsule opacification; capsular bag remarkably clear. No zonulysis, IOL stable at last follow-up (8 y)	No pain and denied blurry vision; 20/50-1 (with old spectacles); IOP 14 mm Hg; IOL well centered with capture configuration (1 wk)

AC = anterior chamber; COPD = chronic obstructive pulmonary disease; DR = diabetic retinopathy; ERM = epiretinal membrane; GERD = gastroesophageal reflux disease; IOL = intraocular lens; NA = not applicable; OSA = obstructive sleep apnea; PCO = posterior capsule opacification; PI = peripheral iridotomy; PMMA = poly(methyl methacrylate); PPV = pars plana vitrectomy; PRK = photorefractive keratectomy; PTFE = polytetrafluoroethylene; PVD = posterior vitreous detachment; PVDF = polyvinylidene fluoride; RD = retinal detachment; RHD = rheumatic heart disease; ZF = zonular fibers

[a]Age at implantation as no explantation was performed

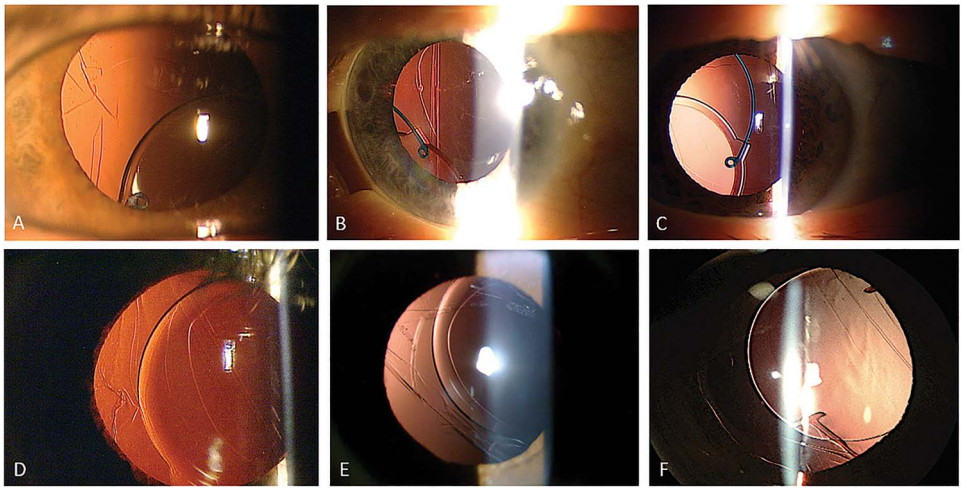

Figure 1. Slitlamp photographs of suspected dead bag syndrome cases, showing remarkably clear capsules. In some cases, the IOL appears to be decentered inside of the bag (*A*, *B*, *C*, and *F*), whereas, in others, the capsular bag also appears to be decentered (*D*, *E*). *A*: Case 1. *B*: Case 3. *C*: Case 4. *D*: Case 5. *E*: Case 6. *F*: Case 8.

available for analysis. To the authors' knowledge, there has been no formal report in the literature on this complication.

METHODS

This study included cases suspected of dead bag syndrome, including cases for which specimens represented by explanted posterior chamber IOLs and capsular bags were available for analysis. Specimens were explanted as part of standard of care and were submitted to the authors' laboratory for analysis, immersed in 10% neutral buffered formalin or in the dry state. Gross examinations were performed and photographs taken using a digital camera coupled with a gross microscope (MU1000-HS, AmScope). All specimens were then evaluated and photographed unstained under a light microscope (Olympus Optical Co., Ltd.).

The capsules containing or without the IOL were processed for complete histopathological examination. After dehydration and embedding in paraffin, 3 μm thick sections were cut and stained with hematoxylin–eosin and Masson trichrome. The sections were examined and photographed under a light microscope, focusing on the morphology of the lens capsule and the presence or absence of LECs, cortical material, and pseudoexfoliation material. The series described by Liu et al. (from the authors' group) of 40 subluxated or dislocated capsular bags containing either an IOL (n = 37) or an IOL–capsular tension ring (n = 3) explanted by 2 surgeons in Germany between December 2011 and June 2013 was used as a control series.[6] The histopathological sections prepared in the authors' laboratory as described earlier and stained with Masson trichrome from each of the 40 capsular bags in that series were reexamined under a light microscope. Twenty-six of them were originally described as exhibiting histopathological evidence of pseudoexfoliation.

Surgeons related to the cases with suspected dead bag syndrome were asked to submit a case summary, including the patient's age, sex, associated general medical and ocular conditions, medications, IOL implantation date, and, whenever applicable, explantation date, signs and symptoms leading to the explantation procedure, and results of the secondary surgery.

RESULTS

Table 1 summarizes the clinical and surgical information available for each case included in this study, with a total of 10 cases. No signs of zonular instability were noted during the implantation surgeries, which were all uneventful. One patient had a history of retinal detachment surgery (case 6), and 1 had previous corneal refractive surgery (case 7). In 7 cases, the IOLs and capsular bags were explanted. All 7 capsular bags and 5 of the 7 explanted IOLs were submitted for laboratorial analysis. Another 3 cases of possible dead bag syndrome were included in this study, although no specimen from them were analyzed. In case 10, only the IOL was explanted (not submitted for laboratorial analysis), but not the capsular bag, and in the other 2 cases (cases 8 and 9), explantation of the IOL or capsular bag was not yet found necessary although, in one of them (case 8), nasal zonulysis has been observed more recently. In at least 3 cases (cases 3, 7, and 10), there was initial subluxation of the IOL inside of the bag, likely through a peripheral defect, whereas the capsular bag itself appeared to be centered. In case 2, there was initial in-the-bag IOL subluxation inferiorly, with subsequent anterior in-the-bag IOL dislocation. In the other cases for which explantation was performed (cases 1, 4, 5, and 6), the reason for explantation was listed as in-the-bag dislocation. However, the clinical photograph of case 4 seems to show that the IOL was decentered, whereas the capsulorhexis opening was still centered (Figure 1).

Considering the 8 cases involving explantation of the IOL alone or the IOL–capsular bag, explantation was performed between January 2018 and March 2021. The mean patient age at explantation was 66.12 years ± 6.42 years, and 6 of the 8 patients involved were men. Six explantation procedures were performed on the left eye. The mean time between implantation and explantation in these 8 cases was 10.6 ± 5.6 years.

In the 7 cases for which the capsular bags were analyzed, the capsule was overall clear without significant cortical material seen during gross, macroscopic examination (Figure 2). There was a small amount of pigment present on the capsule from case 6. Histopathologic examination of the 7 capsular bags showed capsular splitting in 6 specimens and thinning without definite splitting in 1 specimen (Figure 3). LECs were completely absent in capsules from cases 4 and 7, whereas the capsules from the other 5 cases had rare LECs on the inner surface of the capsule. Specimen

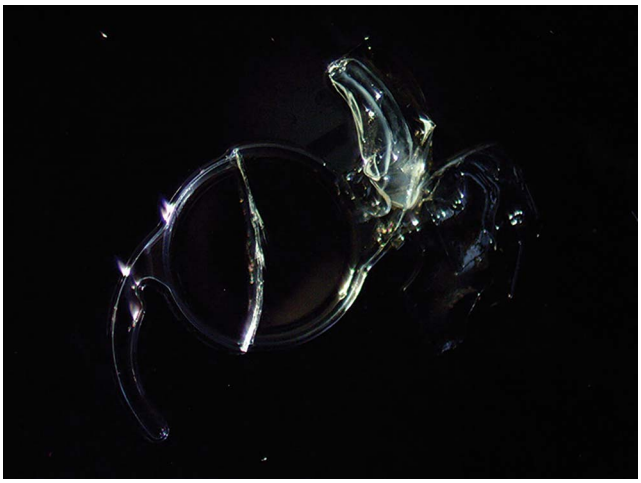

Figure 2. Gross photograph of the explanted IOL and attached capsular bag from case 6 showing the clear capsule with a lack of proliferative material and fibrosis.

from case 6 had small amounts of anterior fibrous metaplasia and pigment deposition. Specimen from case 2 was the only capsular bag that contained a small amount of cortical material on microscopic examination.

The explanted IOLs were either 3-piece silicone IOLs (n = 3) or single-piece hydrophobic acrylic IOLs (n = 2). The optic of the IOL from case 3 showed a small amount of granular pigment deposition in the periphery. Otherwise, the IOLs were unremarkable when examined under light microscopy.

The control series consisted of 26 specimens with histopathological evidence of pseudoexfoliation and 14 specimens without evidence of pseudoexfoliation. In the specimens with pseudoexfoliation, the mean age at explantation was 80.5 ± 6.8 years, with a mean time of 11.9 ± 5.2 years between implantation and explantation. These specimens came from 17 women and 9 men. Associated conditions according to the submitted questionnaires included glaucoma (n = 4), a history of vitrectomy (n = 3), myopia (n = 1), retinal detachment (n = 1), and endophthalmitis (n = 1). The explanted IOLs included ten 3-piece hydrophobic acrylic IOLs, 6 single-piece hydrophobic acrylic IOLs, four 3-piece silicone IOLs, 3 single-piece hydrophilic acrylic IOLs, two 3-piece hydrophilic acrylic IOLs, and 1 single-piece poly(methyl methacrylate) IOL. Proliferated material within the capsular bags (Soemmerring's ring formation) was present in all specimens and was graded as mild in 3 specimens, moderate in 13 specimens, and severe in 10 specimens. LECs were also present in all specimens in some degree, but there were abundant LECs in 16 of the capsules and multiple layers of LECs in an additional 4 capsules. Capsular phimosis was also present in 17 of the 26 specimens. Figure 4 shows the gross, microscopic, and histologic characteristics of one of the pseudoexfoliation specimens. None of them showed any definite capsular bag splitting, although the presence or absence of capsular splitting was not able to be determined in 1 specimen due to sectioning artifact.

For the 14 specimens without evidence of pseudoexfoliation, the mean age at explantation was 71.8 ± 11.9 years, with a mean time of 12.2 ± 4.2 years between implantation and explantation. The specimens were from 9 women and 5 men, and the associated conditions according to the submitted questionnaires were myopia (n = 3), a history of vitrectomy (n = 2), retinal detachment (n = 1), zonular loss (n = 1), retinitis pigmentosa (n = 1), Marfan syndrome (n = 1), and a history of trauma (n = 1). The explanted IOLs included 3 three-piece hydrophobic acrylic IOLs, 1 single-piece hydrophobic acrylic IOL, 2 three-piece silicone IOLs, 3 single-piece hydrophilic acrylic IOLs, and 5 single-piece poly(methyl methacrylate) IOLs. Histopathologic examination of the specimens showed Soemmerring's ring formation in all 14 specimens (mild n = 5, moderate n = 5, and severe n = 4) and capsulorhexis phimosis in 7 specimens. LECs were also present in all 14 specimens but only abundant in 3 of the specimens. Figure 5 shows the gross, microscopic, and histologic characteristics of one of these specimens. There was definite capsular bag splitting in 1

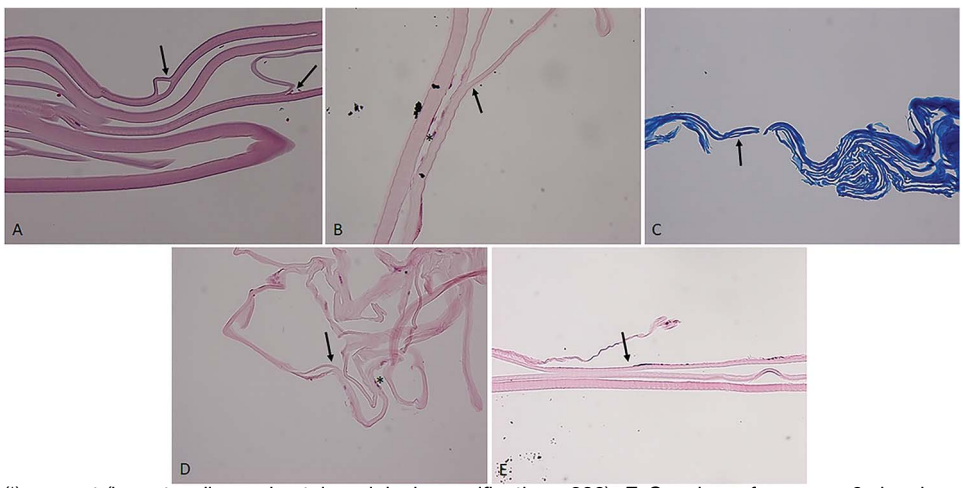

Figure 3. Light photomicrographs of histopathological sections cut from capsular bags from suspected cases with dead bag syndrome. The *arrow* in A-D shows a site of capsular splitting. *A*: Specimen from case 1 (hematoxylin–eosin stain, original magnification ×200). *B*: Specimen from case 3 showing rare lens epithelial cells (*) present on the inner surface (hematoxylin–eosin stain, original magnification ×400). *C*: Specimen from case 4 showing capsular thinning (Masson trichrome stain, original magnification ×100). *D*: Specimen from case 5 showing rare lens epithelial cells (*) present (hematoxylin–eosin stain, original magnification ×200). *E*: Specimen from case 6 showing an area of pigment deposition (arrow) close to the capsular splitting site (hematoxylin–eosin stain, original magnification ×200).

Figure 4. Gross and light photomicrographs of an explanted 3-piece hydrophobic acrylic IOL–capsular bag complex with pseudoexfoliation from the control series. *A*: Gross photograph of the IOL–capsular bag complex showing capsulorhexis phimosis with moderate Soemmerring's ring formation. *B*: Light photomicrograph of the IOL–capsular bag complex showing anterior capsular folds around the small capsulorhexis opening (original magnification ×40). *C*: Light photomicrograph of a histopathological section from the capsular bag showing pseudoexfoliation material on the outer surface of the anterior capsule (*arrow*) and a continuous layer of lens epithelial cells on the inner surface. Proliferative cortical material within the bag can also be seen on the bottom of the section (Masson trichrome stain, original magnification ×100).

specimen (from a case with zonular loss noted clinically) and possible capsular splitting in another. Both specimens showed capsulorhexis phimosis with either mild or moderate Soemmerring's ring formation. The presence or absence of capsular splitting was not able to be determined in 1 specimen because of sectioning artifact.

DISCUSSION

To the authors' knowledge, this study represents the first formal report on the dead bag syndrome. Hirata et al. described signs of capsular splitting or delamination under scanning electron microscopy in 12 non–pseudoexfoliation-related dislocated IOL–capsular bag complexes.[7] They were observed at the equatorial region of the bags, in areas without zonular fibers. The authors speculated that the loss of zonular fibers was due to the capsular delamination. Their specimens were different from those we described in this study, in which the bags exhibited variable amounts of Soemmerring's ring formation and fibrotic capsular changes.

Although the dead bag syndrome specimens reported in this study share characteristics with both true exfoliation and pseudoexfoliation, there are specific differences that show dead bag syndrome to be a distinct entity. True exfoliation syndrome refers to the splitting or delamination of the anterior capsule and is usually diagnosed by visualization of a thin membrane of the delaminated capsule on the anterior surface of the crystalline lens or in the anterior chamber during slitlamp examination before cataract surgery. A double-ring sign may be seen, also known as capsulorhexis masquerade, as it can mimic a partial capsulorhexis with a free-floating flap of delaminated capsule when the sign has progressed far enough. It is usually associated with chronic exposure to an open fire or infrared radiation, such as while working as in a factory or bakery, and advanced age, although there are many idiopathic cases reported. Patients with true exfoliation are typically in their seventies to eighties.[8–17] Teekhasaenee found that the mean age at presentation was 75.2 years in his study of 259 patients with true exfoliation.[8] By contrast, none of the patients with dead bag syndrome in this study had known exposure to high heat or infrared radiation or capsular splitting that was evident on the slitlamp examination. The mean age was lower at 65.7 years, with a range from 56 to 72 years, and none of them had signs of a membrane in front of the crystalline lens before cataract surgery.

Signs of zonular weakness were not observed during the original implantation surgeries in our study. By the time of explantation, however, significant instability of the capsular bag was found in 7 of the 10 cases. In cases 8, 9, and 10, the capsular bag or zonular apparatus still appeared to be able to support the IOL within the bag (8 and 9) or in the sulcus with posterior optic capture (10). Zonular weakness is also not considered a commonly associated finding in true exfoliation. Wong et al. found no zonular weakness in their study on 24 eyes with true exfoliation syndrome that underwent phacoemulsification.[9] Teekhasaenee reported that only 10% of 259 patients demonstrated spontaneous phacodonesis or anterior lens dislocation.[8] It is possible that in both, true exfoliation and dead bag syndrome, in-the-bag IOL dislocation is

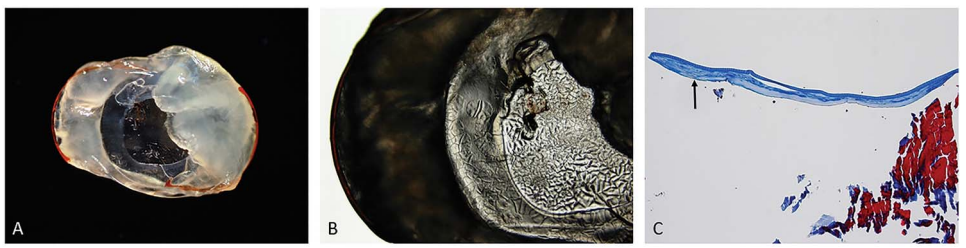

Figure 5. Gross and light photomicrographs of an explanted 3-piece silicone IOL–capsular bag complex without pseudoexfoliation from the control series. *A*: Gross photograph of the IOL–capsular bag complex showing capsulorhexis phimosis with severe Soemmerring's ring formation. *B*: Light photomicrograph of the IOL–capsular bag complex showing the large amount of cortical material within the Soemmerring's ring surrounding the optic (original magnification ×40). *C*: Light photomicrograph of a histopathological section from the capsular bag showing fibrous metaplasia of the anterior lens epithelial cells in the inner surface of the anterior capsule (*arrow*) and no evidence of pseudoexfoliation material. Proliferative cortical material within the bag can also be seen on the right side of the section (Masson trichrome stain, original magnification ×100).

associated with a loss of zonular fibers that is in itself the result of capsular delamination in areas of zonular attachments. Therefore, the weakness may be in the zonular attachments to the capsule, instead of the zonular fibers themselves. We postulate the sequence of events in dead bag syndrome may be capsules lacking LECs exhibiting capsular delamination in areas of zonular attachments that leads to loss of zonular fibers.

Histopathologically, lens capsule splitting, delamination, or schisis is the main feature of true exfoliation syndrome although other findings reported in the literature include thickened anterior capsule, a more lightly staining of the outer layer of the delaminated capsule and vesicles when stained with PAS, and abnormal fibrils in the central capsular layer.[10–13] Varying amounts of LECs were present in true exfoliation specimens previously reported in the literature. In many cases, there were abundant LECs in a single layer, although there was attenuation of the normal layer of LECs in several other specimens, and studies using transmission electron microscopy observed apoptosis progress, shrinkage, pyknosis, intracellular vacuoles, and gap enlargement between cells.[8–17] Our specimens with dead bag syndrome showed similar splitting of the capsular bag, but LECs were consistently and markedly attenuated or even absent under histopathological examination.

Unlike true exfoliation and dead bag syndrome, there is no capsular splitting in pseudoexfoliation syndrome. Hirata et al. examined 7 pseudoexfoliation-related dislocated capsular bags containing IOLs under scanning electron microscopy and found no signs of splitting or delamination.[7] Instead, pseudoexfoliation is characterized by deposition of fibrillary material on the lens capsule, zonular fibers, and many other ocular and extraocular sites.[10] Clinically, the dandruff-like material creates a 3-ring sign on the anterior lens capsule (central zone of visible pseudoexfoliation material 1.0 to 3.0 mm in diameter, combined with a middle clear zone and a peripheral cloudy ring), which can be seen on the slit-lamp examination.[8] Pseudoexfoliation is also associated with zonular weakness as the material weakens the zonular fibers themselves and their anchoring.[5,6] There was no clinical or histopathological evidence of pseudoexfoliation material in any of the cases with dead bag syndrome. In addition, our specimens had only rare LECs and no Soemmerring's ring formation, whereas most of the pseudoexfoliation control samples had abundant LECs and a moderate or severe Soemmerring's ring.

The finding of capsular splitting in one of the control specimens without pseudoexfoliation raises the question whether this specimen could be a case of dead bag syndrome. The patient was a 69-year-old woman with zonular loss observed at the time of IOL dislocation and explantation, which was performed 9 years after implantation. Although the capsular splitting and presence, but not abundance, of LECs in this specimen were consistent with our dead bag cases, there was also capsulorhexis phimosis and a mild Soemmerring's ring, neither of which was seen in any of our cases. Yet, since 1 specimen with dead bag syndrome had a small amount of anterior fibrous metaplasia and another had a small amount of proliferative cortical material; this control specimen could represent a case with dead bag syndrome with slightly different characteristics that could be due to the less profound loss of the LECs.

Although dead bag syndrome has been characterized clinically as a clear, floppy capsular bag that is unable to support the IOL inside of it, the etiology is unknown. In one of the cases described in this study, the patient originally had a white, intumescent cataract. The same surgeon (S.M.) had seen previous cases of white, intumescent cataracts that also evolved into dead bag syndrome, suggesting that there may be a role of oncotic pressure within the capsular bag in killing LECs. However, as most of the cases described in this study were not related to this type of cataract, other factors are also likely involved. In any event, the histopathological findings presented in this study suggest that absence or scarcity of LECs may be a contributing factor as this and capsular thinning and splitting and lack of proliferative material within the bag were the main characteristics on histology. Our study is limited by the relatively small number of cases. Furthermore, for some of them, no specimens were produced for laboratorial analysis. However, the cases described in this study raise the question about the possibility that complete removal of LECs during cataract surgery would lead to degradation of the capsule. In a case report, Moreno-Montañés et al. described a case of a 37-year-old patient with a completely clear capsular bag 6 years after phacoemulsification and IOL implantation.[18] The patient had a history of Acanthamoeba keratitis and had to undergo penetrating keratoplasty, during which the IOL could be moved within the capsular bag without resistance. There were no signs of zonular or capsular weakness, and the authors speculated that the presence of LECs may not be necessary for a healthy capsule. However, it is difficult to confirm the absence of LECs in that case as histopathology was not performed. Studies indicate that LECs may contribute to the health and structural integrity of the lens capsule either through their interaction with the capsule or the production of protective factors.[19,20] The etiology of the dead bag syndrome and the relationship between LECs and capsular strength and integrity need to be further studied. This is especially important given the development of techniques to reduce LECs at the time of modern cataract surgery, such as polishing, in hopes of preventing posterior capsular opacification. Further studies will ascertain whether thorough polishing could lead to an increasing rate of dead bag syndrome.

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Mary Mayfield, HT, John A. Moran Eye Center, University of Utah, assisted with the histopathological preparations.

WHAT WAS KNOWN

- True exfoliation syndrome refers to the splitting/delamination of the anterior capsule, usually diagnosed by visualization of a thin membrane on the anterior surface of the crystalline lens or in the anterior chamber during slitlamp examination before cataract surgery.
- Pseudoexfoliation is characterized by deposition of fibrillary material on the lens capsule, zonular fibers, and other anterior segment structures, being frequently associated with zonular weakness, anterior fibrous metaplasia, and capsulorhexis phimosis.

WHAT THIS PAPER ADDS

- The dead bag syndrome seems to be a distinct entity in which the capsular bag remains very clear many years post-operatively, without fibrotic changes or proliferative material within it, becoming diaphanous and floppy and unable to support the IOL within it.
- The IOL may initially decenter/dislocate through a peripheral defect in the diaphanous capsular bag, and subsequent in-the-bag IOL dislocation may occur because of zonular loss that results from capsular delamination in areas of zonular attachments.

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First author:
Catherine Culp, MD

Department of Ophthalmology and Visual Sciences, John A. Moran Eye Center, University of Utah, Salt Lake City, Utah