

Three-piece intraocular lens in the sulcus with optic capture in patients with mild to moderate zonular weakness in exfoliation

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Purpose: To study the use of sulcus placement of a 3-piece intraocular lens (IOL) with optic capture in patients with exfoliation with zonular weakness. **Methods:** Data on all exfoliation patients who had direct or indirect evidence of zonular weakness and had a 3-piece IOL implanted in the sulcus with optic capture over a 5-year period between January 2017 and January 2022 were included in this retrospective case series. **Results:** The study comprised of 35 eyes of 35 patients. The mean age at surgery of the 20 male and 13 female patients was 75.21 years \pm 5.74 (standard deviation (SD)). The mean pupillary diameter was 5.77 \pm 2.23 mm (range: 10 to 3 mm). A capsular tension ring (CTR) was used in 17 cases and iris hooks as a pupil-expanding device were used in 15 cases. No patients had an increase in inflammation after surgery and there were no late subluxation or dislocation of “in the bag” posterior chamber IOL or major complications. There was a significant improvement in visual acuity. **Conclusion:** The sulcus placement of 3-piece IOL with optic capture is the ideal technique in patients with clinical or intraoperative evidence of mild to moderate zonular weakness. It may also be more appropriate in relatively younger patients (in the fifties or sixties) with exfoliation with no overt zonulopathy to prevent late subluxation or dislocation of “in the bag” IOL.

Key words: Exfoliation, optic capture, pseudoexfoliation, sulcus implantation, three-piece IOL

The occurrence of late subluxation or dislocation of “in the bag” posterior chamber intraocular lens (IOL) is being noted more frequently after previously uncomplicated cataract surgery in patients with exfoliation.^[1,2] The trauma induced due to the surgical procedure itself, secondary traction on the zonular fibers, shear injury from IOL donesis, and capsular contraction are the main reasons for the late dislocation of these posterior chamber IOLs.^[3] The relentless deposition of exfoliative material increases the chance of subsequent dislocation. There is a lack of consensus on the prevention of dislocation of IOL and the management of patients with inadequate capsular support.

Several studies have reported on the safety and efficacy of multiple methods of IOL implantation in patients with inadequate capsular support.^[4-10] These include different methods of scleral fixation, iris fixation, or anterior chamber IOL implantation. However, there is a lack of information on the use of sulcus fixation of three-piece IOLs in patients with exfoliation. Previous studies have reported good visual outcomes although early post-operative inflammation was higher in eyes with sulcus implantation of IOL.^[11] Two studies compared the use of 3-piece IOL with one-piece IOL in the bag in uncomplicated exfoliation.^[12,13] There is no exclusive use of 3-piece IOL placed in the sulcus with optic capture in complicated exfoliation in the literature.

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We present a case series of patients with Exfoliation with zonular weakness, who have undergone sulcus placement of 3-piece IOL with optic capture at Amardeep Eye Care, Kollam, India.

Methods

This was a single-center retrospective case series study. All exfoliation patients who had direct or indirect evidence of zonular weakness and had a 3-piece IOL implanted in the sulcus with optic capture over a 5-year period between January 2017 and January 2022 were included [Fig. 1]. Inclusion criteria were patients aged over 50 years with visually disabling cataracts and exfoliation with direct or indirect evidence of zonulopathy. Exfoliation was diagnosed clinically as the presence of white fluffy dandruff-like material on the pupillary border, the lens capsule, or the angle. In patients with bilateral disease, only the eye with more advanced cataracts was included in the study. Exclusion criteria included a history of trauma, corneal pathology, previous eye surgery, or subjects with decreased vision due to other reasons than cataracts (e.g. exudative age-related macular degeneration, proliferative diabetic retinopathy, inflammatory eye diseases, etc.).

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Direct evidence of zonulopathy includes pre-operative phacodonesis, wider iridolenticular gap, and focal iridodonesis.^[14]

The indirect evidence includes small pupils with the presence of exfoliative material on zonules, posterior iris surface, and pupillary margin, the presence of a brunescient nucleus, and the presence of a shallow anterior chamber in an eye with normal axial length.^[15] Cases were identified using the electronic medical records system of the hospital with external validation using the medical records. The study was approved by the Institutional Human Ethics Committee (IEC No. 116/22). The study adhered to the tenets of the Declaration of Helsinki.

The following parameters were recorded: Corrected distance visual acuity (CDVA), intraocular pressure (IOP), grade of cataract, central corneal thickness (CCT), endothelial cell density (ECD), pupillary diameter, axial length (AL), and the anterior chamber depth (ACD). Surgical videos and notes were carefully reviewed, and the presence of subluxation and use of capsular tension ring (CTR) and iris hooks were noted. Post-operatively, CDVA and IOP at one month and complications, e.g. posterior capsular opacification (PCO), glaucoma, late dislocation of IOL in the bag, capsular phimosis, uveitis, hyphema, pigment dispersion, etc., were recorded.

Procedure

Surgical technique

All the patients included in this study were operated on by an experienced surgeon (JP). The IOL power calculation was the same as that for an “in the bag” IOL. Peribulbar anesthesia (4 ml of a combination of two-thirds lignocaine hydrochloride 2% with one-third bupivacaine 0.5%) or topical anesthesia (proparacaine hydrochloride 0.5% eye drops) was administered.

Pharmacological mydriasis was attempted with a combination of tropicamide 0.8% and phenylephrine 5%.

A temporal clear corneal incision was made using a 2.8 mm steel keratome. Two sideports were created near 12 o'clock and 6 o'clock. Four more sideports were created in the clear cornea at 60° to the surface of the cornea for the capsule hooks if needed. The anterior capsule was stained with trypan blue solution 0.06%. Iris hooks were used if necessary. A soft shell was created by the technique of Arshinoff^[16] by first injecting a dispersive ophthalmic viscosurgical device (OVD) followed by a cohesive OVD.

A continuous curvilinear anterior capsulorhexis of diameter 5 mm to 5.25 mm was created with a conscious effort to maintain the size, shape, and centration. Two-point hydrodissection followed by a rotation of the nucleus was done. Iris/capsular hooks were inserted through sideports and fixed in position if needed.

Phacoemulsification of the nucleus with the stop and chop or divide and conquer technique was done. OVD was repeatedly injected into the anterior chamber to protect the corneal endothelium utilizing the soft-shell technique.^[16] The residual cortex was removed by gentle, tangential pull using bimanual 23G irrigation/aspiration. A CTR was implanted in the bag after inflating it with cohesive OVD. A three-piece hydrophobic acrylic was implanted using an Emerald unfolder (Johnson & Johnson North Jacksonville, FL 32256) after injecting OVD

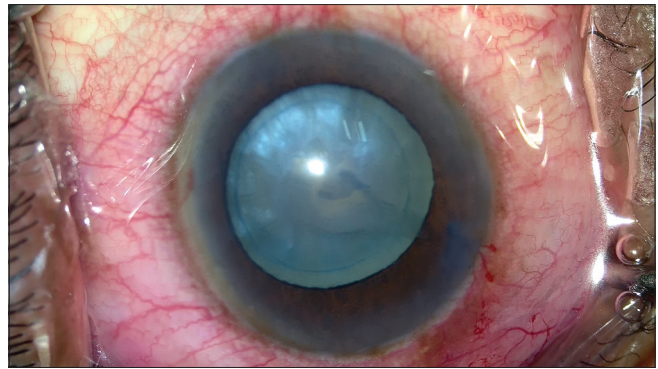


Figure 1: Exfoliative material on the capsule

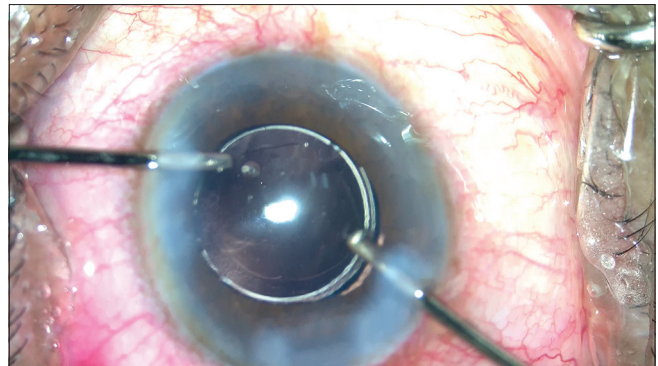


Figure 2: 3-piece IOL placed in the sulcus

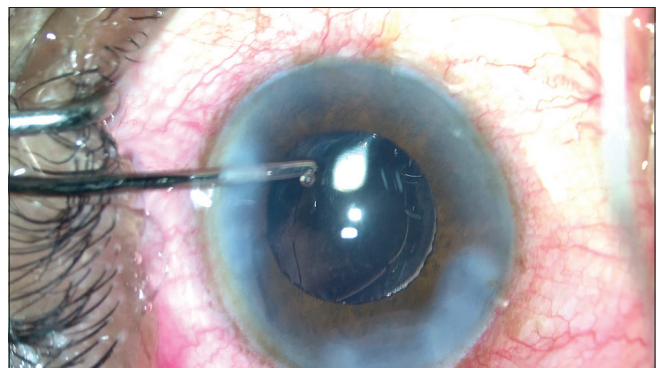


Figure 3: Optic capture of the 3-piece IOL placed in the sulcus

under the iris to lift it away from the anterior capsule [Fig. 2]. The power of the 3-piece IOL used was the same as the power of the “in the bag” IOL based on well-known studies of adjustment of IOL power.^[17,18] Care was taken not to overfill the capsular bag with OVD. Once the leading haptic was in the sulcus, the trailing haptic is dialled in a circular motion to get it into the sulcus with the least trauma to the zonules. The superior sulcus was kept free of haptic by keeping the IOL horizontally oriented for a future trabeculectomy if the need arises. The residual OVD was removed from the anterior chamber and the bag with low flow parameters.

The optic edges 90° away from the haptic-optic junction were nudged posteriorly into the capsular bag to bring about an optic capture while maintaining the anterior chamber with continuous irrigation [Fig. 3]. A peripheral anterior capsulotomy was created with a new 26G needle. This prevents

early capsular distention syndrome. The wounds were closed by hydration with balanced salt solution mostly and 10-0 vicryl/nylon suture whenever essential. Preservative-free moxifloxacin was injected into the anterior chamber.

Post-operatively, prednisolone 1% eye drops, moxifloxacin 0.5% eye drops, and bromfenac 0.09% eye drops were used in tapering doses over 6 weeks. A post-operative spike in IOP was managed with topical antiglaucoma medications.

Statistical analysis

The continuous variables were expressed as means and the categorical variables as percentages. The visual acuity was converted from Snellen to the logarithm of the minimum angle of resolution (logMAR) for analysis. All cases identified were included in the analysis and no cases were excluded. Data was evaluated using SPSS Statistics for Windows software (version 21.0, IBM Corp, Chicago, IL, USA).

Results

We obtained data from 35 eyes of 35 patients with exfoliation who had undergone three-piece IOL implantation in the sulcus with optic capture in the study period. Two patients were lost to follow-up and hence not considered. Of the remaining 33, follow-up was available for 4 years or more for 8 patients, 3 years and more for 13 patients, and 1 year or more for 23 patients. The mean follow-up was for 2 years and 3 months, ranging from 5 years to 4 months. Table 1 shows each patient's baseline demographic and clinical characteristics. Overall, the mean age at surgery of the 20 male and 13 female patients was 75.21 years \pm 5.74 (SD) (range: 89 to 65 years). The mean CDVA and IOP at presentation pre-operatively were 1.40 \pm 0.92 logMAR (range: 3 to 0.4 logMAR) and 15.27 \pm 3.89 mm Hg, respectively.

The cataract was Grade II nuclear sclerosis (NS) in 14, Grade III NS in 2, Grade IV in 1, and Grade V in 1 patient. Six patients had mature senile cataracts, four had immature senile

Table 1: Patient characteristics

Patient No.	Age (Years)	Gender	Eye	Max. pupil diameter (mm)	Cataract	CDVA Pre-op (logMAR)	IOP Pre-op (mm Hg)
1.	75	M	LE	4	NS III	1.6	18
2	77	F	LE	3	IMSC	2	13
3	76	M	LE	8	NS II PSC	1.3	12
4	76	F	LE		IMSC	1.6	13
5	78	M	RE	3	NS II PSC	0.4	9
6	76	M	LE		IMSC	2	11
7	72	F	RE	4	MSC	3	16.3
8	67	M	RE	5	NS III	0.48	10.5
9	65	F	LE	3	NS II	2	16
10	65	F	LE	8	NS V	0.48	14
11	73	M	LE	5	NS II, PSC	0.6	14
12	75	M	LE	3	MSC	2	14
13	87	M	RE	8	NS II	1.1	18
14	71	M	LE	3	IMSC	0.6	11
15	70	M	RE	6	PSC	0.48	12
16	78	M	RE	8	MSC	0.4	16
17	82	F	LE	7	NS IV	1.2	10
18	84	M	LE	5	PSC	0.6	19
19	72	F	RE	3	NS II, PSC	3	18
20	81	M	RE	4	IMSC, PSC	1	12
21	73	M	RE	4	PSC	1	18
22	69	M	RE	7	MSC	3	17
23	89	F	RE	8	NSC II, PSC	0.4	15
24	76	M	RE	8	NS II	1.3	18
25	75	F	LE	10	NS II	3	15
26	72	M	LE	8	MSC	3	10
27	74	F	RE	4	NS II, PSC	1	28
28	80	F	LE	3	NS II	1.1	16
29	84	F	RE	7	HMSC, SUBL	1.6	18
30	74	F	LE	10	MSC	3	17
31	69	M	LE	6	NS II	0.48	15
32	73	M	RE	7	NS II, PSC	1.1	18
33	74	M	LE	7	NS II, PSC	0.4	22

Legend: CDVA=Corrected distance visual acuity, IOP=Intraocular pressure

Table 2: Intraoperative patient parameters

Patient No.	CCT/ECD μm^2 cells/ mm^2	ACD (mm)	AL (mm)	LT (mm)	CTR use	Iris hooks use
1	497/3057	3.06	24.21	3.81	y	y
2	427	2.91	22.92	4.1	y	y
3	499/3088	3.52	23.82	3.95		n
4	550/3334					
5	475	2.54	23.76	4.96	y	y
6	566				n	
7	524	2.99	22.28	3.64	Y	y
8	528/2738	3.03	23.61	5.22	Y	y
9	562/2435	3.58	22.13	3.8	Y	y
10		2.78	21.72	2.9	N	n
11	409/2308	3.20	22.94	3.5	Y	y
12	562/3069	4.79	22.57	5.09	Y	y
13	476/2209	2.95	22.56	3.13	N	n
14	540	3.87	22.9	4.12	Y	y
15	526/2448	4.48	21.83	4.72	Y	n
16	485/2492	2.63	21.39	2.36	N	n
17	528/3638	3.4	23.38	4.7	N	n
18	528/2614	1.65	23.71	3.71	Y	y
19	495/3397	3.1	22.59	2.27	Y	y
20	475/2025	3.21	23.26	4.7	Y	y
21	514/2233	2.94	25.18	4.47	Y	y
22	496/2782	2.02	23.07	5.36	N	n
23	573/2443	3.25	22.7	3.59	N	n
24	520/2368	2.77	23.84	4.96	N	n
25	497/2771	1.51	21.74	3.36	N	n
26	559/3054	3.6	24.62	3.72	N	n
27	599/3293	1.19	23.84	5.47	Y	y
28	519/3385	1.73	21.88	3.79	Y	y
29	567/3770	2.93	21.80	3.71	N	n
30	541/3441	1.96	22.08	4.1	N	n
31	459/2595	2.04	22.11	5.41	Y	n
32	450/2358	2.75	23.50	3.5	N	n
33	520/2289	3.48	23.98	5.13	N	n

Legend: CCT=Central corneal thickness, ECD=Endothelial cell density, ACD=Anterior chamber depth, AL=Axial length, LT=Lens thickness, and CTR=Capsule tension ring

cataracts while one had hypermature senile cataracts. Eleven patients had posterior subcapsular cataracts.

The mean CCT was $514.56 \pm 43.62 \mu\text{m}$ (range: 599 to 409 μm), mean pre-operative ACD was $2.90 \pm 0.81 \text{ mm}$, and the mean ECD was $2801.25 \pm 491.63 \text{ cells}/\text{mm}^2$ (range: 3770 to 2025 cells/mm^2).

Table 2 shows the intraoperative findings in each case. The mean pupillary diameter was $5.77 \pm 2.23 \text{ mm}$ (range: 10 to 3 mm). CTR was used in 17 cases and iris hooks as pupil-expanding devices were used in 15 cases.

The mean CDVA and IOP at 1 month follow up was $0.38 \pm 0.26 \text{ logMAR}$ (range: 1.1 to 0 logMAR) and $13.54 \pm 4.21 \text{ mm Hg}$, respectively [Table 3]. Descemet's membrane folds on the first post-operative day were resolved with conservative therapy alone in all five cases. No patient had capsular distension syndrome or any other major complications. There was no late subluxation or dislocation of IOL. No complications like PCO, capsular phimosis, significant pigment dispersion, or uveitis were noted.

Discussion

This is a case series, which uniquely demonstrates the efficacy, and safety of a 3-piece sulcus placed IOL with optic capture in patients with exfoliation with zonular weakness. There was no late posterior dislocation of IOL in our series. There was a significant improvement in the visual acuity of the patients with minimal complications.

Exfoliation is a progressive condition exacerbated by aging and causes progressive zonular damage. A prospective comparative study of cataract surgery in eyes with uncomplicated exfoliation showed that the risks of IOL decentration and PCO were low and comparable to that of control subjects. It also stated that the outcomes at 5 years were not affected by the choice of IOL (1- vs 3-piece acrylic IOL) or the presence/absence of a CTR.^[12]

Sulcus placement of the 3-piece IOL with optic capture reduces the movement of the IOL thereby providing stability. This is

Table 3: Post-operative patient parameters

Patient no	CDVA post-op (logMAR)	IOP post-op (mm Hg)	Refraction [SE[D]]	Post-op complications	Follow-up duration
1.	0.48	12.1	-0.75-1.75x80 (-1.625)	Nil	3Y 2 mo
2	0	10	Plano		3Y 2mo
3	0.48	10	-1.25x70 (-0.625)	Nil	1Y
4	0.18	11			6Y 2mo
5	0.48	10.2	-1.50x70 (-0.75)	Nil	1Y 7mo
6	0.18	11	plano		3Y 1mo
7	0.6	12.7	-0.25-0.75x60 (-0.625)	Nil	2Y 6MO
8	0	7.4	PLANO	Nil	2Y 9MO
9	0.3	16	-1.5-0.5x90 (-1.75)	Nil	4Y 11MO
10	0.48	18	-3.00		2Y 5 MO
11	0.4	11	-1.5-0.5x70 (-1.75)	Nil	3Y 5 MO
12	0.18	14	-1x110 (-0.50)	Nil	4Y 2MO
13	0.3	14	-0.50-2.50x130 (-1.75)	DM FOLDS	4Y 2MO
14	0.18		-1.5x70 (-0.75)	Nil	4Y
15	0	16	-1.5X10 (-0.75)	DM FOLDS	4Y
16	0.4	8	-1.25x60 (-0.625)	Nil	1Y 3MO
17	1	12	-1.5x90 (-0.75)	Nil	10MO
18	0.3	20	+0.75	Nil	1Y 3 MO
19	0.48	11	-1.25x90 (-0.625)	Nil	1Y 1MO
20	0.18	12	-0.50x90 (-0.25)	Nil	1Y 1MO
21	0.3	17	-1.00-1.00x110 (-1.50)	Nil	10MO
22	0.18	14	+0.25-1.00x60 (-0.25)	Nil	10MO
23	0.3	13	-0.50x180 (-0.25)	Nil	10MO
24	0.3	18	-1.50x90 (-0.75)	Nil	4Y 3MO
25	0.18	13	PLANO	DM FOLDS	4MO
26	0.3	10	-1.25x90 (-0.625)	DM FOLDS	4MO
27	0.48	24	+0.75x130 (0.375)	COR EDEMA	4MO
28	0.4	10	-0.50-1.50x60 (-1.25)	Nil	5MO
29	0.4	16	-1.25-2.25x100 (-2.375)	Nil	4MO
30	0.48	11	-1.25x40 (-0.625)	Nil	1Y 4MO
31	1	8	-2.00-1.25x10 (-2.625)	Nil	4Y 10MO
32	1.1	22	-2.00-1.25x10 (-2.625)	BLEB	3Y 1M
33	0.48	21	-1.00-1.00x110 (-1.50)	BLEB	10MO

Legend: CDVA=Corrected distance visual acuity, IOP=Intraocular pressure, SE=Spherical equivalent

mainly provided by the haptics in the sulcus, which reduces the dependence on the already weak zonules. This stability is most crucial as exfoliation is a progressive condition and would have been instrumental in preventing the late dislocation of the IOL.

The mean time from IOL implantation to dislocation has been described to be ranging from 7 years and 1 month to 8 years and 6 months after surgery.^[2,3,18] These studies did not have any zonulopathy, to begin with. In our study, we have considered patients with direct or indirect evidence of zonulopathy with exfoliation. Hence, we have considered patients with a mean follow-up of 2 years or more.

There has always been a concern that sulcus fixation of IOLs can lead to inflammation which in combination with the inflammation caused by exfoliation *per se*, could lead to greater ocular damage.^[14] We theorize that the inflammation caused

due to the sulcus placement of the IOL would allow greater adhesion of the IOL to the sulcus. This in turn will help in preventing the late dislocation of the IOL.

The optic capture would ensure greater centration of the lens. "In the bag" placement of the optic ensures that IOL power calculation is the same as that for an "in the bag" IOL. There is almost no refractive shift as the capsule securely wraps around the optic, which keeps the capsule from contracting.

Further, the pupillary block is prevented by the optic capture, and the need for a surgical iridectomy is minimized. The optic capture additionally prevents any touch of the optic with the posterior iris surface. Hence a multitude of potential complications ranging from pigment dispersion with or without glaucoma to uveitis glaucoma hyphema (UGH) syndrome can be avoided.^[19]

We find that the chances of capsular distension are higher after optic capture. Our recommendations to minimize capsular distension include (1) washing out as much OVD as possible from the bag using low vacuum and aspiration parameters and (2) performing peripheral anterior capsulotomy. Multiple small nicks on the capsulotomy margin after optic capture help to decrease the effect of fibrosis and consequent capsular phimosis thereby decreasing the stress on the zonules.

We feel that this is the ideal technique to do in patients with clinical or intraoperative evidence of mild to moderate zonular weakness. For patients with severe zonulopathy, additional anchoring techniques like iris suturing or scleral fixation or Cionni ring anchoring are advised. In those with no evidence of zonular weakness, the decision should be based on the age of the patient. As age advances, NS increases progressively and the chances of performing uneventful phacoemulsification under challenging situations like a small pupil and zonular dialysis become higher. In older patients, “in the bag” IOL should be placed but with radial incisions to the rhexis edge at the end of surgery. In relatively younger patients (in the fifties or sixties) with exfoliation with no overt zonulopathy, the 3-piece IOL in the sulcus with optic capture in the bag may be more appropriate.

Muller *et al.*, in a prospective study, found no significant difference in ACD, before or after cataract surgery with “in the bag” IOL implantation, as an indicator of effective lens power, between eyes with exfoliation and non-exfoliation. They also found that cataract surgery induces similar ACD changes in eyes with exfoliation as compared to normal eyes. In their study, ACD changed from 2.54 ± 0.42 mm to 4.29 ± 0.71 mm with a mean change of 1.75 ± 0.74 mm in the exfoliation group before and after phacoemulsification.^[20,21] Tafti *et al.* had ACD changing from a pre-operative mean value of 2.63 ± 0.43 mm to 3.97 ± 0.39 mm at one month after “in the bag” IOL implantation for patients with exfoliation.^[22] It is a limitation of our study that the post-operative ACD was not recorded.

To our knowledge, this is the first report of the use of 3-piece IOLs in the sulcus with optic capture in patients with exfoliation with mild to moderate zonular weakness. Some studies look at 5-year post-operative results and refractive precision in uncomplicated exfoliation, but none with mild to moderate zonular weakness.^[12,13,23,24] Therefore, we could not compare our results with other investigators. Further larger studies with longer patient follow-ups are needed for the evaluation of this very useful IOL technique.

Conclusion

In the bag, subluxation or dislocation of IOL is being increasingly reported in patients with exfoliation. Three-piece IOL in the sulcus with optic capture provides greater stability in patients with exfoliation with mild to moderate zonular weakness. Recommendations for appropriate techniques of IOL implantation in various stages of exfoliation are provided.

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Conflicts of interest

There are no conflicts of interest.

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