Study 3: Assessment of events during surgery on posterior polar cataracts using intraoperative optical coherence tomography

Amar Pujari, Namrata Sharma, Rahul K Bafna, Divya Agarwal

Purpose: To describe the changes along nucleo-epinuclear and the opacity-capsular junction during hydrodelineation and the entire period of phacoemulsification using intraoperative optical coherence tomography (iOCT). Methods: A total of 12 eyes of 12 patients with clinically confirmed posterior polar cataract, who underwent cataract surgery by a single surgeon under the direct guidance of iOCT. The changes along nucleo-epinuclear junction and opacity-capsular junction during/following hydrodelineation and the changes along the opacity-capsular junction following nucleus removal, capsular changes before the opacity removal, and its dynamic changes throughout the surgical procedure were studied. Results: The mean age of patients was 48.25 ± 7.89 years. Eight of them were males and the right eye was operated in seven patients. With regular hydrodelineation, optimal separation of the nucleus-epinuclear layer was evident in 11 patients. Once a golden ring is achieved through the hydro procedure, then repeated attempts can be performed within it to decrease the chances of capsular damage. Fracture of the posterior opacity with tension over the underlying capsule (n = 1), inadvertent hydro dissection while performing hydrodelineation (n = 1), continuous posterior capsular billowing (n = 2), and posterior capsular ruptures (n = 2) were encountered in this observation with even well-judged surgical manoeuvring. Conclusion: iOCT provides a better understanding of real-time changes along different layers of the human lens during posterior polar cataract surgery. The observations obtained here are likely to help in minimizing inadvertent complications in the future.

Key words: Intraoperative optical coherence tomography, in vivo changes in posterior polar cataracts, posterior polar cataract

Surgery on eyes with posterior polar cataracts (PPC) is often a challenging task. Due to its inherent capsular weakness and/or dehiscence, the risk of capsular tear and subsequent complications are not uncommon.[1-4] Beginning from continuous curvilinear capsulorhexis to phacoemulsification to wound closure, every surgical step needs well-planned execution.[1,2,4] The hydrodissection procedure in routine cataract surgery is meant to separate the peripheral lens plate from the capsule, and the hydrodelineation procedure is meant to create separation between the nucleus and the epinucleus.[1] However, due to unprecedented pressure exertion on the posterior capsule during hydrodissection, it is usually contraindicated in PPC cases, hence, instead only hydrodelineation is often preferred to separate the nucleus from epinucleus. During the hydrodelineation procedure, the exact path and direction of fluid currents and most importantly the changes along posterior opacity-capsular junction in real-time are unknown, therefore, to bridge this lacuna in the literature, intraoperative optical coherence tomography (iOCT) study was undertaken to explore changes during crucial steps of posterior polar cataract phacoemulsification.

Methods

Patients presenting to our routine outpatient services for cataract surgery were evaluated. Cases with clinically confirmed PPCs undergoing surgery were included. A total of 12 eyes of 12 patients were inducted with written informed consent. Before the initiation of the study, ethical clearance from the Institutional Review Board was also obtained with strict adherence to tenets of the Declaration of Helsinki.

All 12 eyes (all eyes had nuclear sclerosis grade II-III with PPC) having PPC’s underwent surgery by a single experienced surgeon with his/her own set of skills in these complex cases. Surgery was initiated routinely. A second observer was standing beside the iOCT screen during the whole surgery to continuously focus iOCT along a particular area of interest, that is, along the lower half of the lens (from the mid nucleus to the posterior capsule with prime importance to opacity-capsular junction). The surgical procedure involved surgeons preferred entry wounds followed by regular-sized capsulorhexis, following this, the surgeon performed hydrodelineation from

Access this article online
Website: www.ijo.in
DOI: 10.4103/ijo.IJO_1052_20

Cite this article as: Pujari A, Sharma N, Bafna RK, Agarwal D. Study 3: Assessment of events during surgery on posterior polar cataracts using intraoperative optical coherence tomography. Indian J Ophthalmol 2021;69:594-7.
the main clear corneal wound into 12 o’clock and 6 o’clock positions of the lens (this was to avoid canula shadowing while imaging with iOCT). As the surgeon injected fluid to create a separation of the nucleus from epinucleus, simultaneous real-time iOCT events were evidenced on-screen and recorded. Subsequently, the surgeon observed end real-time OCT findings before proceeding to the next step, and the unnoticed iOCT events were conveyed to the surgeon by the second observer as and when. Subsequently, the surgeon performed nuclear phacoemulsification and reassessed opacity-capsular junction and capsular status under the microscope as well as on the iOCT screen. Now, again based on these results, opacity-cortical matter cleanup was performed followed by polishing the posterior capsule whenever necessary. The intraocular lens was implanted in a capsular bag even in presence of a capsular breach after performing an optimal anterior vitrectomy.

### Results

The mean age was 48.25 ± 7.89 years. The right eye was operated in seven patients and the left eye in five, eight patients were male and four were female. All surgeries were performed by a single surgeon.

The iOCT-guided observations were categorized into four phases:

1. **Changes along nucleo-epinuclear layers during hydrodelineation**

   On iOCT, a normal hydrodelineation fluid jet created a plane of separation between the nucleus and posterior epinuclear plate with no disturbances to opacity-capsular junction [Fig. 1a]. On the surface, the hydro procedure created a correspondingly looking “golden ring;” these dual coordinated findings were observed in 11 cases (whereas in one case inadvertent hydrodissection was noted). Further hydro procedures within the golden ring sent the fluid currents within the lens matter [Fig. 1b], however, any further attempts of hydrodelineation outside the primary hydrodelineation ring (that is, golden ring limits) endangered the opacity-capsular integrity [Fig. 1c and d]. In case 2 (case no. 2), a simple repeat hydrodelineation outside the golden ring led to inadvertent seepage of fluid below the opacity with subsequent capsular stretching, nevertheless, the preexisting intact capsule did not open, fortunately. In the rest of the cases, the separation was fairly reproducible.

2. **Changes along posterior opacity-capsular junction during hydrodelineation.**

   In case no. 3, a well-judged hydrodelineation was performed, however, on iOCT, it was evident that it has caused an inadvertent hydrodissection kind of separation by separating the capsule from opacity [Fig. 2a]. In case no. 4, the usual hydrodelineation procedure created a perfect plane of cortical separation but the fluid current additionally fractured the posterior opacity, this was evident in the surgeon’s view, however, the capsule beneath was not clinically delineated. In this case, timely iOCT imaging showed a clear escape of fluid through the fractured site, again preexisting intact capsule minimized the complications [Fig. 2b].

3. **Capsular status following the removal of nucleus matter and before and after the removal of posterior opacity**

   In cases from 5 to 10 who presented with dense posterior pole opacity, the posterior capsule was intact on anterior segment optical coherence tomography (ASOCT) during preoperative evaluations. The hydrodelineation procedure created perfect separation planes and after nucleus removal reassessment of the opacity-capsular junction was performed on iOCT. A variable separation of opacity from the posterior capsule was observed due to phacoemulsification maneuvering (it was a partial separation in three cases and no separation in rest three). With this information, cortical and opacity cleanup was performed in all six cases.

4. **Capsular dynamics during phacoemulsification**

   In cases 11 and 12, hydrodelineation was optimal and capsular integrity was well-maintained throughout the phacoemulsification procedure, however, following nucleus cleanup, the capsule inadvertently floated towards the phacoemulsification tip. This was observed even with well-maintained anterior chamber pressures and cortical matter in situ. It was more clear on iOCT and it showed undue anterior bowing of capsule (likely suggestive of posterior capsular ectasia), this observation helped in the repeated filling of the anterior chamber with viscoelastic to maintain back pressures. This form of constant posterior capsule billowing was observed in two cases, and due to this, the inadvertent paracentral posterior capsular tear was encountered in the 12th case [Fig. 2c and d].

### Discussion

To avoid capsular dehiscence during surgery, efforts have been made by various surgeons to classify those who are at risk and those who are not. Different surgical techniques have also been described to minimize the risk of capsular rupture.[5,6] Besides, using various imaging modalities preoperative assessment of capsular status is also now in routine practice.[7-9] PPCs have been classified by Lee et al. and Vasavada et al. into different categories depending upon various factors like the extent of central opacity, subcapsular cataract, presence of white spots at the edges, and nuclear sclerosis grade.[2,10] These understandings will help in better surgical planning, however, capsular rupture during any stage of surgery is still possible even with preoperatively predicted intact posterior capsule, therefore, an understanding of intraoperative events, especially capsule dynamics is a must with growing technology.

In our previous observation on modified posterior segment OCT imaging (where a 20 D Volks lens was kept along the aperture of posterior segment OCT and anterior segment structures were screened subsequently), definite dehiscence along the posterior capsule was observed in four eyes out of 26 eyes. The morphology showed a definite loss of capsular continuity with an associated herniation of lens matter along the anterior vitreous (conical sign). All these cases had an intraoperative opening of the posterior capsule. These findings add new observations to the existing literature which can be examined by an ophthalmologist even in the absence of sophisticated ASOCT.[9] In addition to this, in our other previous work, we systematically categorized PPC into specific and generalized morphologies (101 eyes).[11] In that, the specific morphology category included the conical, moth-eaten, and ecstatic types which possessed a greater inherent risk of capsular rupture.[11]

iOCT is now increasingly used in various anterior segment surgeries as it allows real-time monitoring of various surgical
steps. During cataract surgeries, evaluation of parameters such as wound morphology, posterior capsule status in PPCs and traumatic cataracts, depth of trenches, and the status of the capsular bag are known.[12] Herein, we assessed in vivo changes in lens on iOCT to predict real-time events which can predispose for avoidable complications. Our study reaffirms that the hydrodelineation procedure needs to be performed cautiously to separate the nucleus from the epinuclear plate. An inadvertent hydrodelineation outside the existing golden ring might endanger the integrity of the already weakened capsule. After nucleus and opacity removal, capsular integrity must be reassessed for any clues of dehiscence, and if found intact further exercises can be performed with greater accuracy, and, if found dehiscent, appropriate steps can be undertaken to mitigate the gross complications. During the entire period of phacoemulsification, capsular billowing due to its inherent

weakness/octasia was evident in our iOCT-guided observation, therefore, regular anterior chamber filling and anterior chamber pressure maintenance maneuvers were necessary to avoid inadvertent capsular tear. Hence, these are novel observations that have not been discussed in the literature till now.

The major limitations of this study are as follows: 1) small sample size and 2) single surgeon operated cases. Hence, extrapolation of these observations by other surgeons is encouraged. The newer learning points from this study are: 1) novel cross-sectional documentation of intralenticular and posterior capsular-opacity dynamics during various surgical maneuverings. 2) Although these are limited observations, cataract surgeons must include these possibilities in their future surgeries to minimize unseen complications.

Figure 1: (a): Routine hydrodelineation resulted in the formation of a well-defined golden ring under a microscope. At the same time, iOCT showed separation along the nuclear-epinuclear plane with no disturbances to a posterior opacity-capsular junction (white arrow). (b): In the same case further hydrodelineation attempts within the established golden ring area produced separations along the same plane of the nucleo-epinuclear path (white arrow). (c): In the same case any further attempts to hydrodelineation outside the established golden ring led to displacement of the epinuclear plate from posterior opacity (red arrow), thus endangered the posterior capsular integrity (normal separation is indicated by white arrow). (d): In the same further imaging showed an intact posterior capsule (green arrow) with minimal separation between the capsule and posterior opacity.

Figure 2: (a): In another case, the hydrodelineation attempt caused an inadvertent hydrodissection (red arrow), which was not evident clinically but iOCT delineated the separation of capsule from posterior opacity. (b): In another case, hydrodelineation resulted in the fracture of posterior opacity (left red arrow), which was evident clinically but at the same time iOCT showed fracture corresponding (right red arrow) seepage of fluid with minimal capsular distention. (c and d): In a case, following nuclear phacoemulsification, the epinucleus-opacity and capsular complex showed a continuous forward movement (multiple red arrows). In the same case even in presence of a continuous irrigation port and well-maintained anterior chamber pressures, the capsule-opacity complex showed forward bulge. It was very well-appreciated on iOCT, this helped in the regular viscoelastic filling of the anterior chamber to stabilize continuous billowing (multiple red arrows).
Conclusion

To conclude, this pilot observation describes novel real-time intralenticular and capsular changes during surgery on PPCs that helps in understanding the often less thought and/or encountered events during surgery. By considering these possibilities in the future, while performing surgeries on PPC’s, complications can be averted/minimized.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

References

1. Kalantan H. Posterior polar cataract: A review. Saudi J Ophthalmol 2012;26:41-9.
2. Vasavada A, Vasavada V. Managing the posterior polar cataract: An update. Indian J Ophthalmol 2017;65:1350.
3. Osher RH, Yu BC, Koch DD. Posterior polar cataracts: A predisposition to intraoperative posterior capsular rupture. J Cataract Refract Surg 1990;16:157-62.
4. Osher RH, Cionni RJ. The torn posterior capsule: Its intraoperative behavior, surgical management, and long-term consequences. J Cataract Refract Surg 1990;16:490-4.
5. Vasavada AR, Raj SM. Inside-out delineation. J Cataract Refract Surg 2004;30:1167-9.
6. Vajpayee RB, Sinha R, Singhvi A, Sharma N, Titiyal JS, Tandon R. ‘Layer by layer’ phacoemulsification in posterior polar cataract with pre-existing posterior capsular rent. Eye Lond Engl 2008;22:1008-10.
7. Chan TCY, Li EYM, Yau JCY. Application of anterior segment optical coherence tomography to identify eyes with posterior polar cataract at high risk for posterior capsule rupture. J Cataract Refract Surg 2014;40:2076-81.
8. Kymionis GD, Diakonis VF, Liakopoulos DA, Tsoulnaras KI, Klados NE, Pallikaris IG. Anterior segment optical coherence tomography for demonstrating posterior capsular rent in posterior polar cataract. Clin Ophthalmol Auckland NZ 2014;8:215-7.
9. Pujari A, Selvan H, Yadav S, Urgude J, Singh R, Mukhija R, et al. Preoperative assessment of posterior capsular integrity using a posterior segment OCT with +20 D lens: The ‘conical sign’ to suggest capsular deficiency in posterior polar cataracts. J Cataract Refract Surg 2020;46:844-8.
10. Lee MW, Lee YC. Phacoemulsification of posterior polar cataracts—a surgical challenge. Br J Ophthalmol 2003;87:1426-7.
11. Pujari A, Yadav S, Sharma N, Khokhar S, Sinha R, Agarwal T et al. Study 1: Evaluation of the signs of deficient posterior capsule in posterior polar cataracts using anterior segment optical coherence tomography. J Cataract Refract Surg 2020;46:1260-5.
12. Titiyal JS, Kaur M, Falera R. Intraoperative optical coherence tomography in anterior segment surgeries. Indian J Ophthalmol 2017;65:116-21.