

original Article

Phacoemulsification and foldable posterior chamber intraocular lenses in aircrew: Clinical behavior and aero medical implications

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ABSTRACT

The advent of phacoemulsification and foldable IOL for surgical treatment of cataract has drastically shortened the time period to return back to flying in aircrew. However this is not devoid of complications. Hence a follow up of these cases became imperative. 14 experienced aircrew from both civil and military flying, which had undergone phacoemulsification with foldable PC-IOL implants were assessed by an extensive questionnaire study and a detailed objective clinical examination. Among 14 pseudophakic aircrew, 3 had unilateral and 11 bilateral implants. Minor aero medical problems such as haloes around lights, problems with fixed focal length, discomfort, problems due to dust and fumes and distortion of images, did not interfere with their flying. Out of 25 operated eyes reviewed, subluxation of the lens implant occurred in one eye. Opacification of the posterior capsule developed in one eye, requiring YAG laser capsulotomy. Postoperatively, there were 15 emmetropic, 6 hyperopic and 4 myopic eyes and all aircrew attained 6/6 best-corrected visual acuity. The mean absolute spherical refractive error was 0.22 dioptres and astigmatic error was 0.64 dioptres. The mean bifocal add was +1.63 dioptres. Mean intraocular pressure was 15.3+ 2.08 mm Hg. Detailed ophthalmological examination did not show significant clinical abnormality in any of the eyes. Most of the aero medical problems related to older generation IOLs could be eliminated to a significant level by implanting latest foldable PC-IOLs. Phacoemulsification enables the aircrew for an early return to flying by enhancing rapid visual rehabilitation and reducing postoperative complications. Thus the preferred recommended cataract procedure in an aircrew is phacoemulsification with implantation of an ideal-sized highly biocompatible foldable PC-IOL.

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Possession of high standard of vision has been a positive requirement in aviation as more than 80% of the flight information is visually acquired. The development of cataract, which is the opacity in the crystalline lens and its capsule, leads to progressive reduction of visual acuity and also affects the quality of vision and thus severely interferes with the flying career of an aviator [1]. However with the recent technical developments in cataract surgery and intraocular lens implants, replacement in situ of the natural lens by an equally powered intraocular lens restores the physiological parameters of vision to near normal conditions, thus eliminating most of the visual problems associated with cataract and subsequently encountered with aphakic glasses and contact lenses after cataract extraction [2].

Military pilots were credited to be the first recipients of intraocular polymethylmethacrylate (PMMA) implant. The shattered small fragments of PMMA canopy materials due to enemy gun fire which got

lodged in the eyes of aircrew were found to remain inert. This observation was made use by Harold Ridley in 1949, which performed the first IOL implant [3, 4, and 5]. Presently United State's Air Force allows aircrew with IOL implants to fly all types of aircraft whereas, Royal Air Force and IAF allows them to fly transport aircraft only [6, 7]. In India, pseudophakic aircrew have been reflighted for civil

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flying since 1984 and for military flying since 1987 [8,9].

Ever since intraocular lenses were permitted in civil and military flying, a follow up study of these cases had become imperative. Even though the advent of small incision cataract surgery, made possible by phacoemulsification and foldable IOLs, has drastically shortened the time period to return back to flying, it is not without surgical and visual complications. The present study aims to explore the clinical behavior and aero medical implications of phacoemulsification and posterior chamber foldable intraocular lenses in aviation environment. It also discusses the advantages of this procedure over the conventional large incision cataract surgery and older generation rigid intraocular lenses.

Material and Methods

A total of 14 experienced pilots (both civil and military) with a mean age of 52.9 ± 8.1 years who had undergone phacoemulsification and implantation of foldable PC-IOLs participated in this study.

The study was conducted as per the defined protocol, in following stages:-

- (a) A detailed history focused on personal particulars, flying experience and cataract and IOL surgery was recorded.
- (b) An extensive questionnaire proforma was completed by the subject to gather information from the aircrew regarding problems encountered while flying with IOL.
- (c) General external examination of the eyes and adnexae.
- (d) Aided and unaided distant visual acuity was recorded separately for each eye by the standard Snellen's chart from a distance of 6 meters. Near vision and intermediary vision was assessed by using near vision test type chart at a distance of 30 cm and 100 cm respectively. The optical state and

postoperative refractory error of the eyes was assessed by radioscopy.

(e) Visual field testing was done by confrontation test. Color perception was assessed by Martin Lantern test (MLT) for military aircrew and Ishihara book for civil aircrew. Ocular muscle balance was tested by cover test and quantitatively measured by Maddox Rod test. Objective convergence was measured by using Livingston Binocular Gauge. Intraocular Pressure in each eye was measured by indentation tonometry method using Schiottz tonometer. Fundoscopy was done using a self-illuminating ophthalmoscope to exclude any abnormality in the fundi and optical media. Finally a detailed examination of cornea, operative wound, anterior chamber, iris, posterior capsule, position and status of the lens implant and retrolental space was carried out by slit-lamp biomicroscopy.

Results

The aircrew who participated in this study was highly experienced with average preoperative flight time of 10935 ± 2450 hours and an average postoperative flight time of 1850 ± 1450 hours. Out of 14 pseudophakic aircrew, 3 had unilateral and 11 had bilateral implantation. All the eyes had undergone phacoemulsification with foldable PC-IOL implantation. The surgery had been performed between 1998 to 2004. Table 1 gives the data of individual aircrew about their surgery and IOL history.

Two aircrew reported to have a problem with vision due to cataract preoperatively and the disability was severe enough to interfere with flying duty in only one aircrew. The subjective complaints as reported by the aircrew (n=3) included haloes around lights, problem with fixed focal length, discomfort, problem with dust and fumes and

Table 1: History of surgical procedure and IOL: Individual aircrew data

Sl. No.	Subject	No. of eyes operated	Year of surgery		Surgical Procedure		Type of lens implant	Post-op flying time (h)
			Left	Right	Left	Right		
1	Civ/F(P)	BE	Dec 02	Jan 03	Phaco+PC	Phaco+PC	Acrylic foldable	1500
2	Civ/F(P)	BE	Jul 00	Feb 03	Phaco+PC	Phaco+PC	Acrylic foldable	725
3	Civ/F(P)	BE	Feb 04	Mar 98	Phaco+PC	Phaco+PC	Acrylic foldable	6000
4	Civ/F(P)	BE	Mar 00	Apr 00	Phaco+PC	Phaco+PC	Acrylic foldable	2500
5	AF/F(P)	BE	Feb 03	Feb 03	Phaco+PC	Phaco+PC	Acrylic foldable	1 100
6	Civ/F(P)	LE	May 03	NA	Phaco+PC	NA	Acrylic foldable	500
7	Civ/F(P)	BE	Mar 04	Feb 04	Phaco+PC	Phaco+PC	Acrylic foldable	400
8	AF/F(P)	BE	Jul 03	Jul 03	Phaco+PC	Phaco+PC	Acrylic foldable	1000
9	Civ/F(P)	RE	NA	Jun 04	NA	Phaco+PC	Acrylic foldable	100
10	Civ/F(P)	LE	May 02	NA	Phaco+PC	NA	Acrylic foldable	2000
11	Civ/F(P)	BE	Sep 03	Aug 03	Phaco+PC	Phaco+PC	Acrylic foldable	1600
12	Civ/F(P)	BE	Sep 03	Sep 03	Phaco+PC	Phaco+PC	Acrylic foldable	1500
13	AF/F(P)	BE	Apr 99	Oct 98	Phaco+PC	Phaco+PC	Foldable	2500
14	Civ/F(P)	BE	Sep 02	Aug 02	Phaco+PC	Phaco+PC	Acrylic foldable	3000

Note: Civ/F(P) - Civil pilot, AF/F(P) - Air Force Pilot,
 LE - left eye, RE - right eye, BE - both eyes
 Phaco - phacoemulsification, PC - posterior chamber

distortion of image. Out of 25 pseudophakic eyes reviewed, postoperative complications developed in only two eyes. Subluxation of the lens implant occurred in one eye, where the lens was explanted and a new HEMA acrylic lens was reinserted. Posterior capsule opacification developed in another eye, requiring YAG laser capsulotomy.

Visual performance in all the cases after the lens implant surgery was essentially normal. All the aircrew attained 6/6 best-corrected visual acuity for distant vision, N5 for near vision and N14 for intermediary vision. Postoperatively, there were 15 emmetropic, 6 hyperopic and 4 myopic eyes. The residual postoperative refractive errors for the 25 eyes were within the usual values expected. The mean absolute spherical refractive error was 0.22 dioptres, with a range of 0 to 1.75 dioptres. The mean absolute astigmatic error was 0.64 dioptres, with a range of 0 to 1.5 dioptres. The mean bifocal add was + 1.63 dioptres, with a range of + 0.5 to +

3.5 dioptres. Colour perception was assessed to be CP-I for military aircrew and CP-II for civil aircrew. The status of ocular muscle balance and objective convergence was noted to be well within the acceptable standards for aviation duty. The intraocular pressure in the pseudophakic eyes was recorded to be 15.3 ± 2.08 mm Hg. Ophthalmoscopic and slit-lamp examination did not show significant clinical abnormality in any of the eyes.

Discussion

Since the earliest days of aviation, possession of a high standard of vision has been an essential part, as most of the flight information is visually acquired [10]. In the present study even though 13 out of 14 aircrew interviewed, reported to have a problem with vision due to cataract preoperatively, the disability was severe enough to

interfere with flying duty in only one aircrew. In general, cataracts are not particularly serious unless they affect normal vision. Therefore the presence of cataract does not necessarily require restriction from flying duty as long as adequate visual acuity is maintained [11]. However, in aircrew population, surgery may be required earlier to maintain an optimal visual performance because of the peculiarity of the environment where they operate [1]. In the present study, more than 90% aircrew agreed that even though they did not experience much problem preoperatively, they had undergone cataract extraction and lens implantation surgery as advised by the consulting ophthalmologist and felt that they had benefitted from the surgery.

Replacement in situ of the natural lens by an equally powered IOL restores the physiological parameters of vision much superiorly as compared to other methods. As it occupies a position very similar to the crystalline lens, it eliminates peripheral distortion, ring scotoma and restores the full extent of visual field. Also the image magnification is reduced to minimal. Further it abolishes all the difficulties of inserting and removing contact lenses encountered by many people [2, 5, 12].

Aircrews represent a specific sub-set of general population. The type of cataract surgery and IOLs, if needed to be used in this group of people must be highly efficacious and compatible with the operational requirement. In the present study all aircrew had undergone phacoemulsification procedures with foldable PC-IOL implantation. In recent years phacoemulsification has been recognized as the procedure of choice for cataract surgery and has evolved into an effective surgical technique for small incision cataract surgery, permitting emulsification of cataractous lens through a tiny incision. It is possible to remove lens material and implant IOL through an incision as small as 3.0 to 3.5 mm in diameter as opposed to incisions up to

11 - 12 mm in the early days of conventional ECCE. This helps in eliminating many of the complications of wound healing related to large incision. The benefits of this procedure also include safer healing with lesser risk of complications such as inflammation or endophthalmitis, more rapid healing and rapid recovery of visual rehabilitation with less postoperative astigmatism [4, 5, 12].

The subjective appreciation in restoring vision and adequacy of the resulting vision in enabling flying duty was evaluated by a questionnaire study. All the aircrew rated the change in vision after surgery to be highly adequate. IOL surgery as a modality of treatment for correction of aphakia was graded as 'excellent' by 93% and the subjective acceptability of IOL in aviation environment was felt as 'completely acceptable' by all the aircrew.

'Haloes around lights' was observed by one aircrew, which lasted for only one year and then completely disappeared. None of the aircrew complained of increased glare sensitivity. Similar findings have been reported earlier [3,8]. Study carried out by Prasad et al [8], had documented a 20-30% incidence of increased glare sensitivity and halos around lights among aircrew that had undergone conventional ECCE with rigid PC-IOL implantation. Similar problems have been reported in another study [3] compared to much high 40 - 60 % with conventional ECCE and rigid PC-IOLs.

When pupil dilates sufficiently in dim illumination, it exposes the round edge of the optic or the positioning holes of the intraocular lens. This causes light to diffract after striking and results in glare and haloes. This can be overcome by modifying the IOL design, thus inserting IOL of an appropriate size without positioning holes. This has been clearly observed in the present study, where

none of the aircrew with new generation foldable **IOLs**, complained of increased glare sensitivity and only one pilot reported seeing haloes around lights, which lasted only for a short duration of time. This could be due to the edge of the optic interfering with transmission of light.

Even though the problem with fixed focal length was observed by only one aircrew, all of them reported to have difficulties in reading without glasses. This problem is inherent to IOL design [4, 12]. There is a requirement of bifocal spectacle lenses for distance and near vision in a pseudophakic. However, this problem does not appear to be significant in the types of aircraft flown by this group of aircrew. On the other hand multifocal IOLs enhance near vision performance without spectacles. However the use of multifocal IOLs have the disadvantages of minor degradation of visual performance, large loss of contrast sensitivity and problems with color mixing, which makes them questionable for use in aircrew [13, 14].

Discomfort in the form of grittiness in the eye was observed by one aircrew as a rare occasional finding, occurring mostly on exposure to bright light. Similarly one aircrew observed problems with dust and fumes in the early postoperative days. None of these problems interfered with their flying duty at any point of time. Distortion of images was reported by one aircrew who was an old case of astigmatism for the past 20 years for a postoperative period of 30-45 days but disappeared completely afterwards. The above mentioned problems are non-specific and might be expected in any type of intraocular surgery.

Erythroptosis following cataract surgery is a known problem [15]. This is due to loss of ultraviolet blocking property when crystalline lens is replaced by an artificial implant. Previous studies have reported the incidence of erythroptosis between

20-25% [3, 8]. However none of the aircrew in the present study complained of this problem. This may be credited to the use of modern generation high quality foldable IOLs with the U V blocking additive.

Previous history of complications was given by two aircrew. Subluxation of lens occurred in one aircrew, who developed distortion of image and poor vision between 30" - 45" post-operative days. The implant was explanted and a new HEMA acrylic lens was reinserted. The PC-IOL is known to give rise to four specific types of malposition postoperatively: pupil capture, deceleration, windshield wiper syndrome and sunset syndrome [12,16,17]. However, technological advancement in the methods of insertion and retention of IOL as well as development of newer microsurgical techniques has eliminated most of these problems.

YAG laser capsulotomy was done in one eye as it developed Posterior Capsule Opacification (PCO) postoperatively. Earlier studies [8, 13] have reported the occurrence of opacification of posterior capsule between 40 to 60% after conventional ECCE with implantation of rigid PC-IOLs. The lesser incidence of such opacification in the present study can be attributed to the highly biocompatible implant material, as compared to previous generation IOLs.

Posterior capsule opacification is a common sequel of extra capsular extraction [18, 19]. Among many factors, IOL material is one of the important factor attributed to opacification of the posterior capsule. The incidence of PCO was reported to be significantly high for silicon IOLs (27.9%) as compared to PMMA (7%) and is least for acrylic foldable IOLs. The acrylic foldable IOL adheres to the lens capsule more firmly than PMMA and silicon IOL. These differences seem to play a significant role in causing PCO [20, 21]. An adequate YAG laser capsulotomy improves the

vision, where it is impaired and refraction has not helped. The lesser incidence of PCO in the present study can be attributed to the highly biocompatible implant material, as compared to previous generation IOLs.

Conclusion

The evolution of cataract surgery with the introduction of intraocular lens implantation has been one of the major achievements in restoring vision. Intraocular lenses provide a precise pseudophakic optical rehabilitation with minimal magnification and excellent optical properties. The advent of small incision surgery made possible by phacoemulsification and foldable PC-IOLs represents another milestone in this field, reducing most of the postoperative complications thus enabling the aircrew an early return to flying. Most of the post surgery problems, such as increased glare sensitivity, haloes around lights and erythropsia, can be eliminated to a significant level by modifying the IOL design.

Thus the preferred recommended cataract procedure in an aircrew is phacoemulsification with implantation of foldable IOL into the posterior chamber. The ideal IOL should be highly biocompatible, possess a unifocal design and contain an ultraviolet blocking and blue-light filtering additive. Multifocal lenses should not be used in an aircrew and preferably IOL should not have positioning holes.

References

1. Smith P, Ivan D, LoRusso F, Mackersie D, Tredici T. Intraocular lens and corneal status following ac ejection by a USAF aviator. *Aviat Space Environ Med* 2002; 73: 1230-4.
2. Liddy L, Boyd K, Takahashi GY. Cataracts, intraocular lens implants, and a flying career. *Aviat Space Environ Med* 1990; 61: 660-1.
3. Mader TH, Carey WG, Friedl KE, Wilson WR. Intraocular lenses in aviators: a review of the US Army experience. *Aviat Space Environ Med* 1987; 58: 690-4.
4. Dutta LC. *Modern Ophthalmology*. 3rd Ed. New Delhi: Jaypee Publications; 2005.
5. Apple DJ, Ram J, Foster Peng Q. Elimination of cataract blindness: A global perspective entering the new Millennium. *Survey of Ophthalmology* 2000; 45: 1-160. ■
6. Boparai MS. Horizons of visual performance and aviation. *Ind J Aerospace Med* 1998; 42: 1-6.
7. Indian Air Force. *Manual of Medical Examinations and Medical Boards - IAP4303*. 3rd Ed. New Delhi: Air Headquarters; 2003.
8. Prasad GKG, Shingal P. Intraocular lenses in aircrew. *Ind J Aerospace Med* 1995; 39:47-50.
9. DGCA. *Medical assessment hand book for civil aircrew in India*. MIC : 1/99 and amendment vide Air HQ/ 26523/1 I/Med-8. New Delhi; 2004.
10. Ernsting J. *Aviation Medicine*. 3rd Ed. London: Butterworth-Heinemann; 1999.
11. Rayman RB. *Clinical Aviation Medicine*. 3rd Ed. New York. Castle Cannolly Graduate Publishing LLC; 2000.
12. Jaffe NS, Jaffe MS, Jaffe GF. *Cataract surgery and its complications*. 5 Ed. The Mosby Company; 1990.
13. Moorman DL, Green RP Jr. Cataract surgery and intraocular lenses in military aviators. *Aviat Space Environ Med* 1992;63:302-7.
14. Leyland M, Zinicola E. Multifocal versus monofocal intraocular lenses: A systemic review. *Ophthalmology* 2003; 110: 1789.
15. Kamel ID, Parker J A. Protection from ultraviolet exposure in aphakic erythropsia. *Can J Ophthalmol* 1973; 8:563-5.
16. Pearce JL. Experience with 194 posterior chamber lenses in 20 months. *Trans Ophthalmol Soc UK* 1977; 97: 258.
17. Carlson NA, Stewart WC. Intraocular lens complications requiring removal or exchange. *Survey of Ophthalmology* 1998; 42:417-435. Fagadau WR, Maumenee AE, Stark WJ. Posterior chamber intraocular lenses at the Wilmer Institute: a

comparative analysis of complications and visual results. *British J Ophthalmology* 1984; 68: 13-18.

19. Apple DJ, Solaman KD, Assia EJ, Holland EY, LeglerUF. Posterior capsule opacification. *Surv Ophthalmol* 1992; 37:73-85.

20. Ridley H. Intraocular acrylic lenses. *Trans Ophthalmol Soc UK* 1951; 71:617.

Milauskas AT. Posterior capsule opacification after silicon lens implantation and its management. *J Cataract Refract Surg* 1987; 13:644-8