Review Article

Contact Lenses and Flying - A Review

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At present the aircrew of Defence Forces in India are not permitted to fly with contact lenses. Studies conducted in defence establishments of countries like USA, UK, Israel and Sweden found contact lenses compatible with flying. They now permit their aircrew to fly with contact lenses. The behaviour of different contact lenses under various aviation stresses and the advantages and disadvantages of contact lenses in aviation as reported in the literature are reviewed in this article.

Key words : Aviation stresses, bubble formation, lens displacement, visual acuity.

The visual standards[1] followed in Indian Defence Forces at present are : at entry for flying pilot duties glasses are not permitted, but for aircrew other than pilots, the maximum limits of refractive power permitted are (i) hypermetropia +3.50 D, (ii) myopia -2.0 D and (iii) astigmatism ± 0.75 D; for experienced serving pilots of fighter stream maximum limits of ± 3.0 D is permitted. However these pilots are not permitted to fly aircraft where pressure clothing is mandatory. Any difficulty experienced in wearing the glasses with a particular assembly of flying clothing for an aircraft will make the pilot unfit for sorties requiring the use of such flying clothing. For the trained transport and helicopter pilot and aircrew other than pilots, the maximum permitted refractive power limits are ± 3.50 D. Use of contact lenses are not yet permitted in Indian defence flying.

Use of contact lens in aviation has long been a subject of controversy. As the spectacle lenses are not found compatible in flying with different types of headborne equipment viz. pressure helmets, night vision goggles and helmet mounted displays, other optical aids are explored. Contact lenses have been tried and their compatibility in flying under various aviation stresses have been studied by many. In countries like USA, UK, Israel and Sweden, contact lenses are now permitted in military flying.

Evolution of Contact Lenses

The concept of contact lens to correct refractive error is an idea which Leonardo da Vinci suggested wayback in the year 1500. Sir Thomas Young in 1801, so as to correct his own astigmatism, used a 1/4 inch long tube filled with water and a tiny lens placed at its front end and placed it on his eye and called it hydroiascope. In 1888 AE Fick of Switzerland was the first to call it Kontackbrille, which means contact lens. In 1938 Obrig and Salvatori of USA introduced Polymethyl methacrylate (PMMA), the hard lens. In 1948 Kevin Tuohy of USA produced the first corneal micro hard lens. In 1968 the soft contact lens material hydroxethyl methacrylate (HEMA) was introduced in Czechoslovakia[2]. Since then various types of daily wear and extended wear soft and gas permeable lenses came into existence.

Differentiating Points of Contact Lenses related to Aviation

The hard lenses require a significant period for adequate tolerance. They may cause refractive corneal changes that result in blurred spectacle vision. There are certain optical indications for wearing these lenses, such as Keratoconus, high astigmatism etc. They are prone to subcontact lens foreign bodies in dusty environments. They are impermeable to gases. They can be more easily dislodged due to their smaller diameter than cornea. The semisoft or rigid gas permeable lenses have the property of gas permeability, otherwise they resemble the hard lenses in their other properties. The soft lenses contain large percentage of water (38 to 79%). They are gas permeable and flexible. There are certan optical contraindications for their use due to the flexibility. They are immediately comfortable and centre well. They are not easily dislodged due to their larger diameter than cornea. Visual acuity in some cases is not as good as with hard lenses[2].

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Introduction of Contact Lenses into Aviation

United States Air Force (USAF) : A comprehensive review of the introduction and further pursuit of contact lenses in USAF has been made by Tredici and Flynn[2]. USAF first began to show serious interest in contact lenses in 1950 and 21 aircrew were fitted with corneal hard lenses. All of them poorly tolerated the lenses and discontinued wearing them in a short period of time. Again from 1955 to 58 hard vented plastic scleral lenses were tried on 64 pilots and navigators and results were not satisfactory. Improved corneal designs stimulated another study in 1959. In this study 82 USAF flying personnel were fitted with corneal hard lenses and by 1960 only 50% of the original subjects continued wearing them and by 1965 only 3 of the original 82 were wearing their lenses. In another study carried out at USAF School of Aerospace Medicine in 1986, total subjects consisted of 55 aircrew (19 pilots, 9 navigators, 27 other aircrew) wearing contact lenses for optical indications as Aphakia (22), Keratoconus (13) and miscellaneous such as anisometropia, irregular astigmatism and high refractive errors (20). The type of lenses used were hard in 70% and soft in 30%. Out of these 55, 51 were reflighted in all types of aircrafts including fighters though with waivers in some of them and 4 were grounded due to other medical disabilities.

Royal Air Force (RAF) : An environmental study on the flight acceptability of soft contact lenses was conducted in 1984 at Institute of Aviation Medicine RAF[3]. Here a comparative study between contact lenses and corrective flying spectacles (CFS)was made on 17 ametropic aircrew in different aviation environmental schedules. The lenses tried were the soft lenses - snoflex with 50% water content and scan lens with 75% water content. In this study the performance with contact lens wear did not significantly differ from that with CFS.

Israel Air Force : A study was conducted in Israel in 1975 on soft lenses in civil and military aviation under flight conditions of different altitudes, pressures, humidities, accelerations, light and glare. The lenses were found comfortable in all 10 subjects[4].

Behaviour of Contact Lenses under Different Aviation Stresses

Hypoxia and Rapid Decompression : Jaeckle in 1944[5] reported incidence of subcontact lens bubble formation under hard scleral lenses at altitudes greater than 5486m (18000 ft). Later Newsom et al[6] (1968) reported bubble formation in 66% of the 16 corneal hard lens wearers at altitudes greater than 5486 m. They found that two subjects experienced blurred vision from formation of large bubbles under their lenses. Flynn et al[7] conducted studies with rigid gas permeable and soft lenses in hypobaric chambers and onboard USAF transport aircraft for effects of hypoxia. Hypobaric chamber flights ranged from 2438 m (8000 ft) to 7620m (25000 ft), rapid decompression from 2438 to 7620 m (8000 to 25000 ft) and on board transport aircraft with cabin pressure equivalent to 1524 to 2438 m (5000 to 8000 ft) with duration of 3 to 10 hours. At 6096 m (20000 ft) and above all the five subjects with rigid gas permeable lenses showed sub-contact bubbles at edges and two of them also showed central bubble formation. With soft lenses bubble formation was detected in 24% out of 46 subjects; but they were located at limbus. There was no measurable degradation in vision or corneal integrity with both types of lenses.

In another study by Flynn et al[8] soft lens wear was tested in hypobaric chamber. Vision and physiological responses of cornea were monitored by testing visual acuity, contrast sensitivity and slit lamp examination on 10 subjects at 7620 m for 75 min and 8 subjets at 3048 m for 4 hours and 4 subjects in dry air with 5% relative humidity at 3048 m altitude. Results indicated that there was no visual deterioration in all the 10 subjects at 7620 m. At 3048m for 4 hours and in dry air studies, some of them showed grade I minimal signs such as conjunctival injection, corneal vertical striae, epithelial staining, and tear debris. There was no measurable degradation in vision in many of the subjects. Brennan and Girvin[3] reported no bubble formation with soft lenses tested at altitudes of

3658 m (12000 ft) and 8230 m (27000ft) and during rapid decompression from 2438 to 11582 m (8000 to 38000 ft). Eng and Rasce *et al*[8] studied the atmospheric effects at 6096 and 9144 m (20000 and 30000 ft) on soft contact lens wear and found no change in visual acuity, refraction, keratometry and lens placement. No gas bubbles were found. Only moderate increase in scleral injections were seen at both altitudes.

Under effects of hypoxia and rapid decompression there is a possibility of subcontact lens bubble formation and corneal oedema. The quantity of gas that can remain dissolved in a solution is directly proportional to its partial pressure and its solubility coefficient in a given medium (Henry's law). The small bubble nuclei that already exist in solution can expand as the pressure decreases (Boyle's law) and if trapped by an impermeable or semipermeable membrane may grow large enough to be observed. Bubble nuclei may form in areas of negative hydrostatic pressure such as those which may be produced from the contact lens tear pump. The occurrence of bubble formation and their duration is predictably related to the overall gas transmissibility of the contact lens. At sea level the oxygen partial pressure of ambient air is about 155 mm Hg but this decreases rapidly with increasing altitude. A contact lens placed between the source and the cornea must possess sufficient oxygen transport properties to meet the critical oxygen pressure of 11 to 19 mm Hg at anterior corneal level to prevent effects of hypoxia and permit a normal state of corneal hydration.

Acceleration : Polishuk and Raz[4] of Israeli Air Force and Nilsson and Rengstroff[10] of Swedish Air Force reported that pilots with soft lenses undergoing manoeuvres upto +6 Gz reported no subsequent complaints. On human centrifuge,Forgie and Meek[11] tested soft lenses upto +6Gz and found small amounts of decentration which they believed would not interfere with vision. Flynn et al [12] quoted an unpublished data of Tredici and Welsh noting significant lens decentration with hard lenses at +6Gz. Brennan and Girvin[3] tested soft lenses at +4 and +6 Gz and found profound fall in the visual acuity in some subjects at +4Gz (30%) and +6Gz(80%) and this fall was attributed to retinal ischaemia leading to grey and black out. Lens displacement was found in 50% of eyes and the maximum displacement was 1.5 mm at +4 Gz and +1.75 mm at +6Gz. Flynn et al[12] reported similar reduction in visual acuity at +6 and +8Gz with soft contact lens wearers, emmetropic controls and spectacle wearers. The potential for lens decentration and dislodgement during periods of aircraft acceleration generating high gravitational forces is high. When these forces act tangential to the cornea i.e., along the z axis (Gz) the lens decentration would be maximum and may cause deterioration of vision.

Pressure Breathing : Brennan and Girvin[3] reported no significant effect on soft contact lenses with pressure breathing at 30 and 70 mm Hg for 1 min.

Vibration : Brennan and Girvin[3] reported that the subjects wearing soft lenses showed the expected decrements in visual acuity at 6 and 8 Hz of vibration and found no significant difference compared to corrective flying spectacles.

Climatic Testing : Brennan and Girvin[3] reported no significant effect on soft lenses during exposure to heat at 50°C and cold at -26°C for 1 hour.

Advantages vs Disadvantages of Contact Lens in Aviation

On the basis of the available data from laboratory and field studies on the use of contact lenses in aviation,its advantages and disadvantages have been reported as follows[2,3] :

Advantages :

(a) Ease of integration with devices like pressure helmet, helmet mounted displays, night vision goggles, respirators and other optical sights.

(b) Lenses do not mist or fog.

(c) There is unimpeded field of vision as the lenses move along with the movement of eyes.

(d) They are indicated in certain ophthalmic conditions such as keratoconus, irregular astigmatism etc.

(e) No significant reflections are found.

(f) Bulk is negligible and hence no problem of weight

(g) They cannot be easily dislodged or broken.

Disadvantages :

(a) Intolerance by some individuals

(b) Foreign bodies under lens in dusty environment would compromise lens wear.

(c) Maintenance of lens hygiene is difficult in battle field conditions and professional eye care is required for fitting and follow up.

(d) Replacement of lens is difficult in field environment

(e) Bubbles may form under the lens at high altitude

(f) They do not protect the eyes from blunt trauma or flying debris.

(g) In chemical warfare they first act as barriers but later act as sponge to prolong the effect of chemicals.

(h) They may give rise to serious ocular pathology due to infections.

Conclusion

From the above review it is observed that the advantages in the use of contact lenses in aviation outweigh its disadvantages. It is therefore concluded that (i) the contact lenses are compatible with safe flying, (ii) soft contact lenses are preferred to other types, (iii) with head borne equipment only contact lenses are indicated and (iv) selection of subjects depends on optical indication and individual tolerance.

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