Contact Lens Wear During +Gz Acceleration

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The use of contact lens in aviation has long been a subject of controversy. Of great concern in military aviation is the potential danger of the contact lens decentration and displacement with decompensation of visual acuity during periods of acceleration which generate high gravitational forces mainly tangential to the cornea such as along the Z-axis (+Gz). The effects of positive acceleration on the three types of contact lenses hard, gas permeable and soft, were tested on 15 ametropic subjects in a human centrifuge. These subjects were subjected to repeated acceleration runs on the centrifuge upto the greyout level. The visual acuity before and during centrifuge runs was tested on a reduced Snellen's chart at 1m. Video monitoring and recording of the contact lens position during the run was done. In this study, the hard lens showed maximum displacement, with a greater loss of visual acuity, the soft lens showed minimal displacement with minimal loss of visual acuity and gas permeable lens showed intermediate response.

Key Words: Corrective spectacles in aviators, human centrifuge, lens displacement, visual acuity.

Corrective flying spectacles have been the accepted method of correcting refractive errors in aircrew. However, the advent of newer types of comfortable contact lenses has brought in an entirely new concept in correction of refractive errors in aviation. It is true that any spectacle, no matter how well it is designed, may cause visual problems in flight and is found to be incompatible with pressure helmet, new generation NBC warfare support gear, night vision goggles, eye protective devices and helmet mounted sights.

As the contact lens is worn directly on the cornea, it gives an unimpeded field of view, does not mist, and offers ease of integration with pressure helmet and other optical devices. The introduction of contact lens into aviation may allow ametropic aircrew to fly all types of aircraft with different types of head borne equipment. The behaviour of contact lens under various aviation stresses is under study. One of the aviation stresses, common with the high performance aircraft is positive acceleration[1]. On exposure to accelerations during flying, there exists a potential danger of contact lens decentration and dislodgement, compromising visual accuity. This problem is of special concern when increased gravitational forces are tangential to the cornea such as +Gz.

In this study, the effect of positive acceleration on hard, rigid gas permeable (RGP) and soft lenses was tested on a total of 15 ametropic subjects in the human centrifuge.

Material and Methods

A total of 15 ametropic, volunteer subjects from whom informed consent had been obtained, participated in the study. All the subjects were highly motivated, free of ocular pathology and had other ocular parameters within normal limits.

A self illuminating, Snellen's chart was fabricated for reading at 1m, and this was mounted on the front panel of the human centrifuge gondola at head level.

Out of the 15 subjects, 10 were given soft contact lenses (with water content of 38% in 5, 50% in 3 and 78% in 2) and 5 were given high DK rigid gas permeable lenses (RGP). Five subjects, two of the soft lens group and three of the RGP lens group, were also tested with hard contact lens.

These contact lenses were fitted with accepted methods and 4 weeks of successful contact lens wear was mandatory before centrifuge testing. Visual acuity measurements, before, during and after the centrifuge run were done. Displacement of the contact lens was also looked for during the run over the closed circuit TV.

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+Gz tolerance of subjects wearing anti G suit was determined using the microprocessor controller. At an onset rate of 0.5 G/sec and deceleration rate of 0.1G/sec, the +Gz tolerance of the subjects with anti-G suit was determined.

To determine the decrement in visual acuity and displacement of contact lens during +Gz acceleration, a 'step ladder' +Gz profile was set up on the microprocessor controller, upto the tolerance limit of the individual with a 10 sec plateau at 4G and 5G or PLL limit, whichever occurred earlier. During the plateau phase, the subject was asked to read the reduced Snellen's chart at 1 m distance and monitored on the closed circuit TV and intercom. Each eye was tested separately by covering the other eye with a pad. The displacement of contact lens was graded as follows :-

+	:	mild displacement (less than 2mm)
++	:	moderate displacement (2-5mm)
+++	:	Severe displacement (5-8 mm)
++++	:	Major displacement, outside the corneal margin (8 mm)

A detailed examination of the eye including slit lamp examination, was also carried out before and after the run to evaluate :-

(a) Position and mobility of contact lens
(b) Evidence of circum corneal congestion
(c) Visual acuity decrement.

Results

The uncorrected visual acuity of the subjects ranged from 4/60 to 6/9 and corrected visual acuity in all the cases was 6/6 in each eye. The diopteric power of the contact lenses ranged from -0.50 to -4.75D. One of the RGP lens wearer required correction only in right eye (subject 14).

Table I shows the changes in visual acuity at +4 and +5 Gz. Majority of the eyes fitted with soft lenses did not show any decrement. Visual decrement of 6/9 only was seen in 15% of eyes at +4Gz and 65% of eyes as +5Gz. In cases fitted with RGP lenses visual decrement of 6/9 was seen in all eyes except one eye which showed upto 6/12 at +4Gz. At +5Gz, vision deteriorated to 6/12 except except in two eyes which showed 6/9. In case fitted with hard lenses, visual decrement of 6/12 in 40% of eyes and 6/9 in 60% of eyes was seen at +4Gz. At +5Gz, 60% of eyes showed decrement of 6/18 and 40% showed 6/12. The soft lens (all three types) showed the minimum decrement and hard lenses the maximum decrement where as RPG lenses showed an intermediary response.

Displacement of lens could not be observed in 30% of eyes at +5 Gz due to drooping of upper eye lid, consequent to +Gz forces. Majority of soft lenses did show any discernible displacement. Mild displacement was noticed in one eye (5%) at 4 Gz and in 8 eyes (40%) at +5 Gz. The RPG lenses showed mild displacement in 7 eyes (78%) at +4 Gz. At +5 Gz, 3 eyes (33%) showed mild displacement and 6 eyes (67%) moderate displacement. On the other hand, hard lenses showed mild displacement in 8 eyes (80%) and moderate displacement in 2 eyes (20%) at 4 Gz and all eyes (100%) showed moderate displacement at +5Gz. The soft lenses (all three types) showed no or minimum displacement, and hard lenses showed maximum displacement whereas the RPG lenses showed the intermediary response.

Table I Deterioration in vision and the displacement of lens (mm) on exposure to +4Gz and to +5Gz when subjects wore different types of lenses. The specific degree of deterioration is mentioned in the text.

Types of Lens	No. of Eyes tested	Vision deterioration at +4Gz	Vision deterioration at +5Gz	Lens displacement at +4Gz	Lens displacement at +5Gz
Soft 38%	10	3	7	1	6
Soft 50%	6	1	3	0	2
Soft 78%	4	0	3	0	0
RGP	9	9	9	7	9
Hard	10	10	10	10	10

Discussion

The fitting characteristics of soft, RGP and hard lenses are distinctly different[2]. Hard lenses are fitted within the corneal diameter with a spherical base curve that approximates the

central corneal curvature. Lens centration is achieved by tear fluid forces, flattening of peripheral cornea and by superior eyelid holding the lens in place. The RGP lenses have the additional property of gas permeability through the lens and offer lower specific gravity[6]. Soft contact lens, on the other hand, contain a large percentage of water, are flexible and larger than the corneal diameter. The lenses also cover the peripheral cornea and limbus and rest on corneal apex and sclera. Since the sclera is considerably flat, soft lenses centre well and move very little[2].

In the present study, compared to the soft lenses, the hard and RGP lenses showed greater displacement in majority under the effects of +Gz acceleration. This can be attributed to the difference in fitting characteristics and properties of lenses. The hard and RGP lenses being smaller in diameter than cornea, even mild to moderate displacements have compromised visual acuity. The soft lenses being larger in diameter with more optical zone, mild displacements have not caused any considerable decrement in visual acuity. The behaviour of hard lenses showing more deterioration in visual acuity consequent to displacements than RGP lenses can be explained by the property of gas permeability which has some restriction on the mobility of the lens. The minor decrements in vision without displacement of the lens can be attributed to the compromise in the blood supply in the retina related to the effects of positive acceleration which may finally result in greyout and blackout.

Conclusion

It is concluded that soft contact lenses are most suitable for aircrew flying high performance aircraft since these are least displaced and cause nil or minimal decrease in visual acuity during positive accelerations. However, aircrew fitted with the hard and RGP lenses, if given due to any optical indication, are suited to fly only transport and helicopter aircraft.

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