Effects of refractive surgery in extreme altitude or space

The important thing is not to stop questioning.
Albert Einstein

The stability and function of a normal healthy visual system can be influenced by circumstances such as great depth or high altitude.[1–3] As refractive surgery changes the properties of the cornea and the lens, concerns about refractive or intraocular lens (IOL) procedures in humans exposed to extreme situations have been raised.

Early in the 1990s, it was reported that incisional refractive surgery could influence vision in higher altitudes, eg, when radial keratotomy (RK) had been performed in mountain climbers or hikers.[4] An acute hyperopic shift in subjects who had radial keratotomy (RK) and then experienced altitude exposure has been reported and observed at altitudes as low as 2744 m (9000 feet).[A] A dramatic example of this phenomenon was the experience of Dr. Beck Weathers in the Everest tragedy of May 1996, in which 8 climbers also lost their lives. Dr. Weathers had bilateral RK years before the expedition. He noted a decrease in vision starting early during his ascent. Author Jon Krakauer[5] wrote that "…as he was ascending from Camp Three to Camp Four, Beck later confessed to me, 'my vision had gotten so bad that I couldn't see more than a few feet.'" This decrease in vision forced Dr. Weathers to abandon his quest for the summit shortly after leaving Camp Four and nearly resulted in his death. Another report describes 2 expert climbers who experienced hyperopic shifts of 3.0 diopters or more during altitude exposures of 5000 m (16 400 feet) or higher on Mount McKinley and Mount Everest.[A] One report noted no refractive change after 6 hours in post-RK eyes at a simulated altitude of 3659 m, suggesting that the hyperopic shift requires more than 6 hours to develop. There is strong evidence that the effect of altitude exposure on post-RK eyes is caused by hypoxia rather than hypobarism and that breathing a normoxic inspired gas mix will not protect against the development of hypoxic corneal changes.

There is compelling evidence for myopic mountaineers that excimer laser sugery instead of RK is their refractive surgical procedure of choice.[A] Individuals who have had RK and plan to undertake an altitude exposure of 2744 m (9000 feet) or higher while mountaineering should bring multiple spectacles with increasing plus lens power. However, excimer surgery behaves differently. Mader et al.[6] have shown that surface ablation with the excimer laser (photorefractive keratectomy [PRK]) did not lead to corneal flattening and the hyperopic shift at higher altitude that they found in RK patients. As RK has been more or less abandoned, corneal surgery with the excimer laser is the focus of interest when extreme pressure situations are looked at.

Currently, the most commonly performed laser refractive surgery is laser in situ keratomileusis (LASIK), so a 2003 investigation of the visual experiences of climbers with prior LASIK is of interest. Dimmig and Tabin[7] reported visual acuity of 12 LASIK eyes of 6 Mount Everest climbers: 3 climbers noted no problems and perfect vision at the summit of Mount Everest; 1 reported mild blurring with ascent above altitudes of 16 000 feet that improved with descent or a prolonged stay at altitude; 2 climbers reported blurred vision at 27 000 and 28 500 feet, respectively, which improved with descent. The authors conclude that LASIK surgery represents a good option for people who engage in high-altitude activities such as climbing. Nevertheless, in extreme altitudes above 26 000 feet (7900 m), patients should be aware of possible fluctuation in vision. Other studies[8,9] of mountain climbers who had LASIK have also concluded that LASIK may be a good choice in high altitude activities but those achieving extreme altitudes should be aware of possible fluctuation in vision. Data suggest that a small refractive shift in the myopic direction may be present at extreme altitudes. Post-LASIK dry eye may play a role in this environment with such low ambient humidity. Climbers who do not ascend beyond moderate altitudes should not experience a post-LASIK refractive shift.

When space exploration started with the first man-made object to orbit the Earth, the USSR's Sputnik1 in 1957, and later with the first moon landing by the American Apollo 11 craft in 1969, a new area for investigation of the visual system in extreme situations began. For astronauts, rigorous vision standards were initially required. However, as refractive surgery reduces the dependence on glasses or contact lenses, the procedures should be tested for astronauts entering space.

In 1999, Mader et al.[10] documented excellent and stable vision in an astronaut during space flight after bilateral cataract surgery with IOL implantation. Ocular examinations demonstrated stable bilateral posterior chamber IOLs. The mission specialist reported excellent vision during liftoff, 18 days of microgravity, changes in cabin pressure, and reentry, which led to the conclusion that IOLs are safe, effective, and well tolerated during space flight.

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In this issue, Gibson et al. (pages 1486–1491) describe the effects of PRK in an astronaut during a 12-day Russian Soyuz mission to the International Space Station. They found that PRK is likely a safe, effective, and well-tolerated procedure in astronauts during spaceflight. After return, refraction, keratometry, corneal topography, and wavefront aberrations were largely unchanged.

Currently, only Russia and China maintain human spaceflight capability independent of international cooperation. It seems that now and in the future more and more private nongovernmental activities in space flights will take place. This will make it necessary to take a closer look at ophthalmic issues in respect to vision and ophthalmic surgery. The unusual and interesting report about "refractive surgery performed in man entering space" may show the way for future science in this area of our field.

Thomas Kohnen, MD, PhD, FEBO

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