

# The Ascent of Mount Everest Following Laser in situ Keratomileusis

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## ABSTRACT

**PURPOSE:** To report the visual experiences of climbers with prior laser in situ keratomileusis (LASIK) for myopia at extreme altitudes, including the summit of Mount Everest.

**METHODS:** We measured the visual acuity of 12 LASIK eyes of 6 Mount Everest climbers at base camp (17,600 ft). Results are reported on their subjective visual experiences, as all climbers ascended above 26,000 feet and four reached the 29,035-foot summit.

**RESULTS:** Five of the six climbers reported no visual changes up to 26,400 feet. Three climbers noted no problems and perfect vision with their LASIK eyes on the summit of Mount Everest. One reported mild blurring with ascent above altitudes of 16,000 feet that improved with descent, or a prolonged stay at altitude. Two climbers reported blurred vision at 27,000 and 28,500 feet, respectively, which improved with descent.

**CONCLUSION:** Laser in situ keratomileusis may be a good choice for patients involved in high altitude activities. Patients achieving extreme altitudes of 26,000 feet and above should be aware of possible fluctuation of vision. [*J Refract Surg* 2003; 19:48-51]

Mountain climbers, skiers, and hikers often reach altitudes greater than 10,000 feet and rely on stability of vision for safety. This same cross-section of people is often interested in refractive surgery. The highly publicized disaster on Mt. Everest in 1996 included an account of Dr. Beck Weather's visual difficulties secondary to

radial keratotomies, resulting in the present public and academic skepticism regarding refractive surgery at altitude.<sup>1</sup> Multiple studies have looked at the effects of high altitude on the cornea after radial keratotomy, yet little is known about the effect of hypobaric hypoxia on the cornea after laser in situ keratomileusis (LASIK).<sup>2-6</sup> With LASIK now representing the most common refractive surgery in the United States, it is important to study the effects of high altitude on the refraction and stability of the cornea after LASIK. Three published case reports exist of LASIK at high altitudes. Davidorf reported stable uncorrected visual acuity and refraction in a patient who was above 11,000 feet for 10 days, 14,000 feet for 4 days, and 16,000 feet for 1 day in Bolivia.<sup>7</sup> White and Mader reported on a patient who noticed a significant myopic shift after 2 nights spent at 18,000 feet while ascending 19,500-foot Alpamayo in Peru.<sup>8</sup> Recently, Boes and colleagues reported on two climbers who experienced a similar myopic shift while climbing to the 22,841-foot summit of Aconcagua in Argentina.<sup>9</sup> No reports on the performance of LASIK above these altitudes have been published.

Climbing and trekking in the Himalaya involves significant time above 16,000 feet. Climbing Mt. Everest by the traditional South Col route typically requires at least 1 month at base camp (17,600 ft) and multiple trips up the mountain to Camp 1 (20,000 ft), Camp 2 (21,300 ft), and Camp 3 (24,000 ft) for acclimatization. The final summit push for the average climber consists of one night each at Camps 2, 3, and 4 (26,400 ft) and then to the summit of 29,035 feet. Climbers that reach the summit spend approximately 36 to 48 hours at and above 26,400 feet. Such extended time at and above 17,600 feet provides an excellent model to study the effects of hypobaric hypoxia on the cornea after LASIK. We studied at the visual acuity and subjective visual experience of 12 eyes of 6 climbers on Mount Everest after LASIK.

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The authors have no proprietary interest in the materials presented herein.

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**Table**  
**Objective and Subjective Visual Acuity of Six Mt. Everest Climbers After LASIK**

Climber	Time Since LASIK	Age (yr)	Preoperative Refraction (D)	Postoperative UCVA*	UCVA at 17,600 ft	Altitude Reached (ft)	Subjective Report While Climbing
A	3 mo	31	-2.00 OU	20/15 OU	20/20 OU	29,035	No complications 17,600 ft to 28,000 ft. 28,500 ft. and above "milky" that resolved below 27,000 ft on the descent.
B	6 mo	28	-6.75 OD -6.50 OS	20/15 OU	20/20 OU	29,035	No complications
C	3 yr	50	-3.50 OU	20/20 OU	20/20 OU	27,500	"Blurred" vision at 27,000 ft, which worsened by 27,500 ft. Back to baseline 36 hours later while descending.
D	3 mo	27	-2.50 OD -4.00 +1.00 x 90° OS	20/20 OU	20/20 OU	29,035	No complications
E	6 wk	45	-4.00 +1.00 x 90° OD -3.50 +0.75 x 90° OS	20/15 OD 20/20 OS	20/20 OU	29,035	No complications
F	6 mo	48	-4.50 OD -4.25 +0.25 x 90° OS	20/20 OU	20/30 OU	26,400	Mild "blurring" with ascent that would improve after descending back to base camp. Did not impede climbing.

\*Uncorrected visual acuity

#### PATIENTS AND METHODS

We followed the course of 12 eyes of 6 patients who previously had myopic LASIK and climbed above 26,000 feet on Mt. Everest. All climbers used supplemental oxygen at and above 26,400 feet. All had excellent surgical results with all eyes seeing at least 20/20 uncorrected at sea level. Uncorrected visual acuity was measured at the 17,600-foot base camp at a standardized distance of 20 feet using a Snellen eye chart. Subjective reports of visual performance while climbing and at base camp were obtained.

#### RESULTS

Four of the six climbers successfully reached the summit and all of the climbers reached Camp 4 at 26,400 feet, spending at least 24 hours at or above that altitude. Time since surgery, preoperative refraction, postoperative uncorrected visual acuity and at base camp, along with altitude reached and brief subjective descriptions of visual performance at altitude are presented in the Table. Climbers A through E maintained uncorrected visual acuity of 20/20 at base camp and reported no visual changes up to 26,400 feet. Climbers B, D, and E reached the

summit of 29,035 feet and had no complications. Climber F reported mild blurring during ascent above altitudes of 16,000 feet, which improved with descent or stay at an altitude for approximately 24 to 48 hours. This was correlated with decreased uncorrected visual acuity (20/30 OU from 20/20 OU) at base camp that improved to 20/20 after multiple days at that altitude. Climbers A and C reported visual changes above 26,400 feet. Climber A described a "milky" that started at 28,500 feet and explicitly stated that he was "not myopic" and could see just as well far away as he could up close, except for the fact that he was looking through haze. He continued to the summit and descended with some difficulty secondary to decreased vision. He reported that the milky receded at 27,000 feet. Climber C reported a similar incident starting around 27,000 feet and worsening as he ascended, turning him around at 27,500 feet. He described his vision being "blurred" and "like looking through waxed paper." It took 36 hours for his vision to normalize while descending. Time since surgery was not correlated with complications. All eyes returned to pre-climb visual acuity upon return to base camp at 17,600 feet.

### DISCUSSION

Refractive surgery has garnered a bad reputation in the wake of the publicity surrounding one climber's visual complications after radial keratotomy when attempting to climb Mt. Everest in 1996. It has not been published, but several top mountaineers have had radial keratotomy and reached the summit of Mt. Everest and reported no visual problems. Notably, Neal Beidelman, one of the guides who saved the lives of many of the clients in 1996, had radial keratotomy in 1982. He had no visual changes or problems on the summit of Mt. Everest in 1996 (personal communication, 2002).

One of the authors of this paper climbed to the summit of Mt. Everest using contact lenses up to 26,400 feet and spectacles to the summit. Subjectively, it was difficult to see through drying contact lenses and to prevent glasses from fogging. Preventing glasses from fogging is even more problematic when using supplemental oxygen. This does not include the problems of cleaning contact lenses on prolonged expeditions and keeping glasses clear in inclement weather. Thus, refractive surgery is an attractive option for climbers.

Visual complications at such extreme altitude also occur in climbers who have not had surgery. In 1988, Czechoslovakians Dusan Becik, Joseph Just, Peter Bozik, and Jaraslov Jasko attempted the Southwest Face of Mt. Everest, alpine style without supplemental oxygen. After spending 3 nights above 26,000 feet, in the last radio transmission before all four perished, Dusan Becik reported that three of the four climbers were blind.<sup>10</sup> Whether the loss of vision was the result of corneal edema, retinal ischemia, or cerebral ischemia will never be known. Several other emmetropic climbers have also reported visual problems at extreme altitudes.

The rate of corneal hydration and thus swelling has been shown to increase as oxygen tension decreases.<sup>11</sup> Hypoxic swelling in normal corneas is asymmetric yet does not alter refraction. The inelastic anterior fibers of the cornea maintain curvature and thus refraction in the setting of swelling, while the posterior fibers are displaced posteriorly.<sup>12</sup> It is thought that the radial incisions of radial keratotomy result in preferential peripheral corneal edema when exposed to hypoxia.<sup>6</sup> Such structural compromise manifests as central corneal flattening and a hyperopic shift that has been documented in multiple studies of radial keratotomy at altitude.<sup>2-6</sup> This may explain why younger climbers with accommodative reserve might not notice decreased vision with radial keratotomy at altitude.

Less rigorous research exists about the cornea after LASIK at altitude. White and Mader hypothesized that the LASIK lamellar incision alters the structural dynamics of corneal adaptation to hypoxia.<sup>8</sup> In a recent goggle study, they compared 40 LASIK to 40 control eyes exposed to 2 hours of anoxia versus ambient air.<sup>13</sup> The LASIK corneas exposed to anoxia had a statistically significant central corneal thickening and myopic shift when compared to the control corneas. They theorized that anoxia causes stromal corneal thickening anterior to the incision, thus steepening of the anterior cornea and a myopic shift.<sup>13</sup> Their case report of a climber with LASIK at altitude along with the two case reports of Boes and colleagues seem to support this evidence<sup>8,9</sup>, yet Davidorf reported a LASIK patient who reached 16,000 feet and maintained stable refraction.<sup>7</sup>

In the present study, up to 26,400 feet, only climber F experienced blurred vision. The etiology of his blurred vision and decreased visual acuity to 20/30 may have been dry eye keratitis, a myopic shift, or even a hyperopic shift given his age. Climber F had previously attempted to climb Mt. Everest before his refractive surgery. He remarked, "...all in all, the advantage of not having glasses on Everest far out-weighed any loss of visual acuity I had on the mountain."

Climbers A through E reported no visual changes up to 26,400 feet and climbers B, D, and E reported no visual changes on the summit at 29,035 feet. Their subjectively stable vision could represent refractive stability of the LASIK cornea or an unnoticed myopic shift secondary to postoperative hyperopia. Climbers A and C both reported visual difficulties at 28,500 and 27,000 feet, respectively. Although we can only conjecture on the mechanism, it is possible that both climbers experienced corneal edema or corneal surface changes from dry eye induced by oxygen flow from the face mask. It is difficult to ascertain if a myopic shift accompanied their difficulties, but importantly the change compromised their ability to climb.

Interestingly, the amount of time since surgery did not predict complications. Of the two climbers that had significant difficulty, one had surgery 3 months prior to the climb (climber A), and the other 3 years prior (climber C). Climbers D and E, who had surgery 3 months and 6 weeks prior, respectively, reached the summit without visual changes. A previous study on radial keratotomy at altitude found that the hyperopic shift decreased with increasing time since surgery, suggesting that

corneal healing promotes greater refractive stability.<sup>4</sup> Boes and colleagues also theorized that early exposure to altitude stress might contribute to the fluctuations in visual acuity experienced by their climbers who were 8 and 14 weeks after surgery.<sup>9</sup> Our findings suggest that this rule may not be consistent across all patients.

The majority of climbers, skiers, and trekkers do not reach altitudes above 26,000 feet and therefore the fact that 5 of 6 climbers had subjectively stable vision up to 26,400 feet is encouraging. Climbers in the Himalaya may also be encouraged since three climbers reached the summit of Mt. Everest without visual difficulties. Climber E, who has previously summited Mt. Everest six times using contact lenses, noted "having LASIK was the best training for Everest I've ever done... the view from the top (7th summit) was the best I've ever had."

Although four of the climbers reported no or minimal visual changes, the visual difficulties experienced by climbers A and C above 26,400 feet is of concern. Regardless of the etiology, the cornea after LASIK may be prone to complications and compromise in vision above 26,000 feet. Of course, many climbers who have not had refractive surgery have also reported visual difficulties at these extreme altitudes. A prospective, case-controlled study with rigorous examination at extreme altitude would be necessary to elucidate many of the current questions surrounding this issue.

LASIK may be a good refractive surgery option for myopic patients who participate in high altitude activities. All climbers considering LASIK should be

aware of potential visual difficulties at high altitude, particularly those reaching altitudes greater than 26,000 feet.

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