Contact Lens Use by US Army Aircrew on Operation(s) Desert Shield/Storm

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The purpose of this study was twofold: To determine the feasibility of soft contact lens wear under extreme field conditions and to provide an interim readiness fix for aircrew spectacle incompatibility problems. Under this Desert Shield/Storm program, 344 subjects were fitted with one of two types of extended wear soft lenses on a disposable basis. Initial and followup data included recording of visual acuity, slit lamp examination, tear break-up-time (BUT) assessment (both with and without lenses), and a Schirmer tear test (without topical anesthesia). Comparison of the initial vs followup clinical evaluations yielded no statistically significant difference in appraisal of the visual acuity, tarsal conjunctiva, corneal edema assessments, tear BUT (with and without lenses), tear production, and bulbar conjunctiva. Moderate to highly significant differences were evident in evaluation of fluorescein staining of the cornea ($p < 0.01$), rose bengal staining of the bulbar conjunctiva ($p < 0.001$), and limbal injection ($p < 0.001$). One case of ulcerative keratitis was reported within this study group, yielding a calculated incidence of one case per 172 subjects per year. Lens wear received subjective approval from the test subjects despite the seasonal temperature extremes and the unusually dry, dusty conditions. Fewer lens-related complications were seen than had been anticipated by the study group. Based on this field experience, it is concluded that routine contact lens use by Army aircrew can be a viable alternative for spectacle compatibility problems.

In September 1990, the general aviation version of a developmental chemical protective mask was identified for early fielding in Southwest Asia without any type of accompanying spectacle insert or outsert to provide manifest refractive error correction. The Army Surgeon General, in response to an Aviation Systems Command (AVSCOM) request, granted a blanket waiver to existing regulations so that all spectacle-wearing aircrew deploying to Southwest Asia had the opportunity to be fitted with contact lenses. Therefore, all affected aircrew (pilots, crewmembers, maintenance personnel, and medical support personnel) were examined on a volunteer basis for possible contact lens wear under the administrative aegis of an on-going Army-wide contact lens research protocol originally restricted to Apache and Special Operations units only.[5,6] While the primary objective was to provide an interim readiness fix in response to an equipment shortfall, the secondary objective was to obtain a controlled evaluation of contact lens wear under extreme field conditions.

Eleven Army optometrists and 11 Army ophthalmic technicians performed the contact lens work-ups at over a dozen US locations and three locations in Europe. Additionally, one team provided initial and close-out organizational work in Saudi Arabia in October/November 1990 and March/April 1991, while four of the teams permanently deployed to Saudi Arabia in direct support and for the duration of Operation(s) Desert Shield/Storm (ODS/S) from December 1990 through April 1991. The original Army-wide Apache and Special Operations protocol earlier mentioned included 238 subjects, while the Desert Storm or general aviation expansion added 344 subjects, for a combined total of 582 subjects participating in two protocols. Although approximately 450 of the 582 contact lens-wearing subjects served in southwest Asia on Operation(s) Desert Shield/Storm, this report is limited to a discussion of the 344 general aviation subjects fitted with soft lenses solely for this combat deployment. The other subjects' data and experiences will be discussed in separate publications.

The authors recognize those optometrists participating in the CONUS and USAREUR phases of the fitting program: Lt Col Randy Dellinger, Maj Chuck Adams, Maj Dale Patrick, Maj Joe Maranto, Cpt Tom Dunham, and Cpt Tom Mack. The detailed administrative coordination of this progressive effort by Col Gene Channing guaranteed that the available assets were in the right place at the right time.

Methods

Every volunteer subject was given an initial, 24-hour, and 1-week examination at the location of deployment mobilization. The basic examination included recording of visual acuity, slit lamp examination, tear break-up-time (BUT) assessment (both with and without lenses), and a Schirmer Tear Test (without topical anesthesia). During the slit lamp examination, a rating scale of "0 to 4" was used to categorize the tarsal conjunctiva, gross level of corneal hydration or edema, bulbar conjunctiva, degree of circumcorneal vascularization, limbal injection, rose bengal staining of the bulbar conjunctiva, and fluorescein staining of the cornea.

The "with lens" tear BUT determination was made using a high molecular weight liquid fluorescein preparation, while the "without lens" tear BUT was determined using standard fluo-

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rescein strips wetted with sterile saline. Schirmer tear production testing was done using commercially prepared strips of litmus paper placed under the lower lid just temporal to the inferior lacrimal punctum of each eye. Since there were several investigators involved in the protocol, this placement technique was used in an attempt to minimize inter-investigator variance. A topical anesthestic was not used, secondary to investigator concerns about preparation stability in extreme temperatures.

Once the determination that a successful fit had been accomplished at the conclusion of the 24-hour followup examination, lens application and removal training was provided. A 7-day followup examination was performed to ensure adequate initial adaptation to extended lens wear. Quarterly followup examinations were conducted on-location in Southwest Asia (primarily in Saudi Arabia). Twelve weeks worth of materials (48 lenses and four boxes of unit dose wetting solution) were issued after the 1-week examination and after each quarterly followup examination.

This ODS/S protocol used a two-tier contact lens fitting system, with the initial lens of choice being a moderate to high water content (58% water; etafilcon) disposable, extended wear soft lens. The backup for those subjects that were unsuccessful with the first lens was a low water content (38% water; polymacon) standard, extended wear soft lens utilized on a disposable basis. Rigid gas-permeable (RGP) lenses were not specifically fielded for this general aviation protocol extension because of concerns with possible foreign body intrusion from blowing dust and dirt. Desert Shield/Storm subjects were advised to follow a conservative, nominal 3-day/2-night wearing schedule. The subjects were instructed that the night or sleep-period immediately after lens removal was to be passed without any new lens wear. Worn soft lenses were to be discarded immediately after removal, and new lenses were not to be applied until awakening. The terms day and night are used in a relative sense here because many of the subjects were on reverse-cycle operations.

Results

There were 501 volunteers for contact lens evaluation; 344 subjects were successfully fitted with one of the two soft contact lens types. There were 215 subjects fitted with the 58% water content lens, and 129 fitted with the 38% water content lens. The 157 unsuccessful attempts fell into four general groupings: poor physical fit resulting from extremely flat and steep corneas, high astigmatism with poor visual acuity, bifocal-dependency in the cockpit, and preexisting medical condition precluding soft lens wear (Fig 1). Aircrew occupational categories were pilot, crewmember, medical support, and maintenance support. Flight duties were performed on seven different aircraft, the vast majority (97.4%) were rotary wing. Mean subject age was 29.5 years, with the ages ranging from 18 to 47 years. The refractive error distribution varied from −5.50D to +2.75D, peaking at −1.00D (Fig 2).

Statistical comparison of the initial vs followup clinical evaluations by

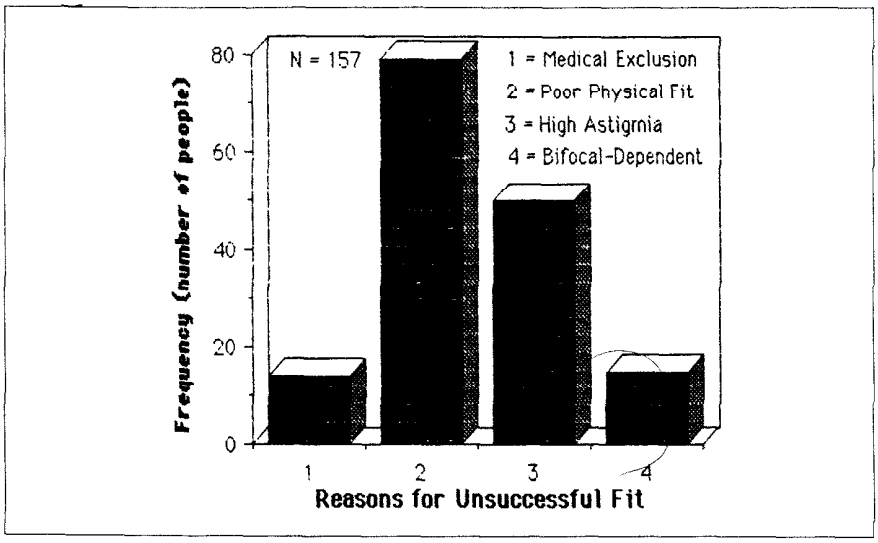

Figure 1. Unsuccessful fit distribution.

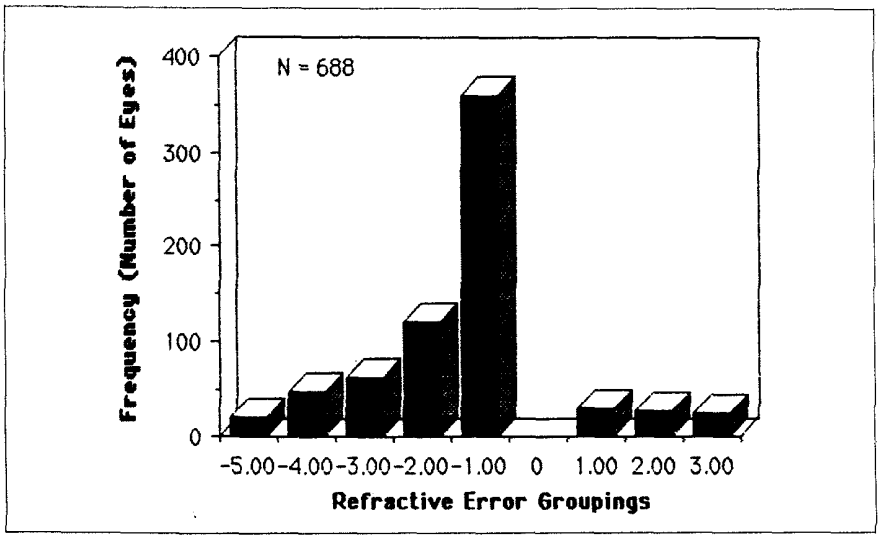

Figure 2. Refractive error distribution.

two-sample nonparametric analysis yielded no statistically significant difference in appraisal of the visual acuity ($p = 0.87$), tarsal conjunctiva ($p = 0.32$), corneal edema assessments ($p = 0.27$), tear BUT with and without lenses ($p = 0.18$), tear production ($p = 0.13$), degree of circumcorneal vascularization ($p = 0.09$), and bulbar conjunctiva ($p = 0.08$). Moderate to highly significant differences were evident in evaluation of fluorescein staining of the cornea ($p < 0.01$; Fig 3), rose bengal staining of the bulbar conjunctiva ($p < 0.001$; Fig 4), and limbal injection ($p < 0.001$; Fig 5). Type of soft lens worn was not a statistically significant factor.

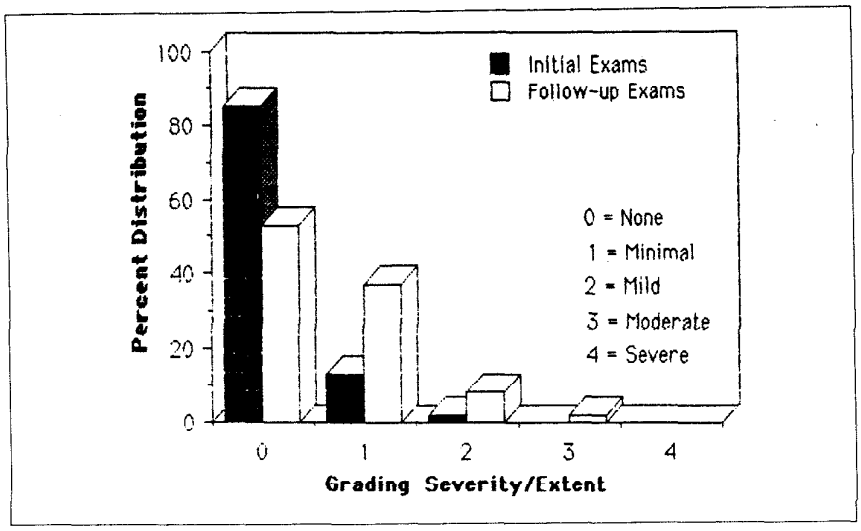

Figure 3. Fluorescein staining.

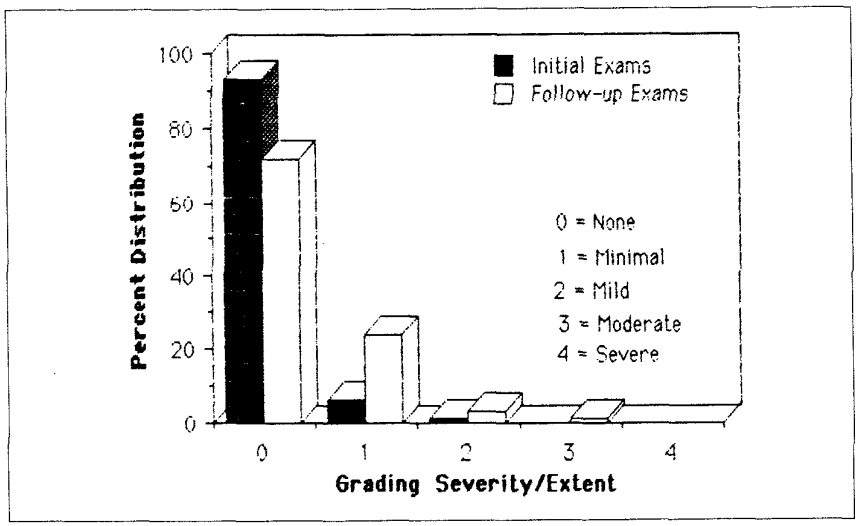

Figure 4. Rose bengal staining.

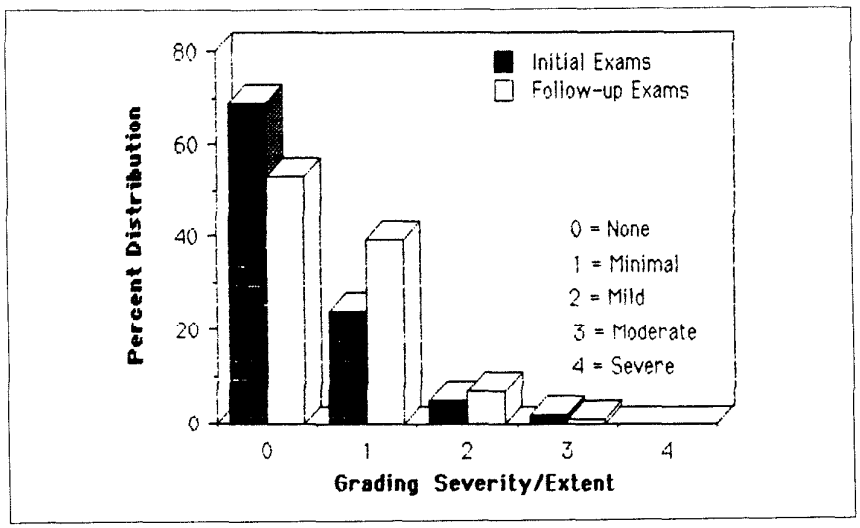

Figure 5. Limbal injection.

Discussion

The successful fitting of 344 subjects out of 501 volunteers yielded a 68.7% success rate. The criteria for fitting success was the achievement of clear, comfortable vision free of any significant ocular tissue disturbances. The documented success rate is considerably lower than the 85% to 88% success achieved in other military-associated contact lens studies.[1,12] However, there were only two brands of lenses used in this study; and they were identical in diameter (14.0mm) and very similar in base curve (8.8mm and a nominal 8.7mm). Since diameter and base curve play significant roles in the achievement of an acceptable physical fit, higher success rates could be achieved with a greater variety in available lens parameters.

The addition of a planned replacement toric lens would also serve to increase overall fitting success. However, subjects dependent on bifocals in the cockpit and those with medical conditions that contraindicate contact lens wear would not be affected by these material changes. Therefore, fitting success could never approach 100%; a more realistic ceiling is plausibly near the previously referenced range of 85% to 88%, with a practical success rate expectation more reasonably near 75% to 80%.

Despite the harsh conditions exis-

tent in Southwest Asia, the clinical picture of contact lens wear was much better than anticipated by the investigators. There was no evidence of pronounced physiological decompensation. However, the presence of mild fluorescein corneal punctate staining, low-grade conjunctival rose bengal staining, and increased limbal injection indicated adverse surface tissue effects.

Rose bengal will highlight dead or devitalized tissue; the cornea did not exhibit any rose bengal staining. However, staining was seen on the exposed conjunctiva outside the peripheral edge of the lens, implying a protective effect by the lenses from an external environmental stressor. Since the sand and dust of Southwest Asia is very alkaline, it is possible that a portion of the rose bengal finding was a reflection of the constantly blowing sand and dust. While staining was noted in all quadrants, it was more prominent inferiorly. The subjective clinical impression was that the soft lenses were acting as a sponge, drawing moisture from adjacent conjunctival tissue.

Fluorescein will highlight breaks in the surface barrier function of the superficial epithelium. While fluorescein uptake was seen conjunctivally, most often it was associated with a break in the corneal epithelial barrier which was seen as punctate staining. The vast majority of these observations were associated with fine, scattered punctate staining that was graded at level 1 or 2 on a 0 to 4 scale. Again, the subjective clinical impression was of a contact lens-induced tissue water or moisture loss. It is hypothesized that the staining represented dry environment-induced lens dehydration, serving to stimulate the wicking of moisture from the corneal epithelium, a process termed pervaporation by Refojo.[11] While this process was identified by Refojo in high water content lenses only, we're suggesting its presence in medium water content lenses exposed to an unusually dry environment.

As an additional step, the rose bengal and fluorescein data were analyzed as a function of the number of days extended lens wear. If lens-induced water loss from the tissue was the appropriate model for both the rose bengal and fluorescein staining processes, then they would both follow a similar pattern over an extended wear period. The rose bengal data followed an initial pattern of increased conjunctival devitalization and then stabilization. This matched lens water content measurements that were taken over the same time period. Therfore, conjunctival devitalization associated with extended soft lens wear could serve as an indicator of lens dessication.

The fluorescein data exhibited the same initial rise and leveling off but then increased again later on. These processes suggest that the extended soft lens-stimulated deficit in the corneal epithelium's barrier function is not secondary to a desiccation process alone. An adjunctive hypothesis suggests corneal metabolic waste accumulation under the soft lens that eventually proves toxic to the corneal epithelium. However, a dual-process challenge to epithelial integrity does not apparently enter into play until after five to six days of extended lens wear; this time period, then, should represent the absolute maximum duration for continuous soft lens wear.

The higher a minus power lens, the thicker its edges will be. Thicker lens edges have been implicated in increased limbal stress and irritation.[2] Low minus lenses have proportionately thinner edges and are less likely to cause corneal limbal injection. Because the lens power distribution in our subject sample peaks at a relatively low −1.00 diopters (Fig 2), excessive peripheral lens thickness has been ruled out as a cause for the limbal injection seen on followup examination in our subjects. It is our subjective impression that the limbal injection was a response by the local vascular system to the hypothesized combined processes of soft lens dehydration and metabolite trapping. However, it is acknowledged that limbal injection has long been recognized as a clinical condition commonly associated with soft contact lens wear.[9]

Overall, lens-wearing subjects' eyes were placed under some surface stress. This was possibly due to the very dry relative humidity and irritating, alkaline dust and sand. However, the combined processes discussed above were certainly contributory. Tear production, as measured by the Schirmer tear test, and tear stability, as measured by breakup time, were unchanged over the course of the study, as were other indicators of stress (corneal edema, tarsal conjunctiva, and bulbar conjunctiva). Therefore, although some statistically significant changes were observed, they were considered to be clinically significant only within the context of modeling the ocular response to extended soft contact lens wear. None of the findings discussed thus far were outside the parameters of clinical conditions commonly encountered in a contact lens practice. This is an important observation in terms of the decision process regarding the potential for routine contact lens use by Army aircrew.

A less commonly encountered condition, but nonetheless highly significant, is the increased risk of ulcerative keratitis. One case of ulcerative keratitis occurred during the overall course of the Desert Storm general aviation deployment. There were no ulcers documented within the study sample during the deployment and combat phases of the operation; the one ulcer that did develop occurred during preparations to redeploy back to home bases. The ulcer location was in the corneal supratemporal midperiphery near the superior lid margin. Lesion size was 1mm to 1.5mm in diameter with irregular margins involving approximately 20% of corneal depth. Its appearance was consistent with that experienced by another subject participating in the preliminary

Apache research protocol.[7] Cultures and/or corneal scrapings were not obtained. Treatment was provided with topical neosporin and fortified tobrex on an in-patient basis. Visual acuity returned to the pre-infection level of 20/20. Based solely on the 344 Desert Shield/Storm subjects over the 6-month deployment, the manifest risk for ulcerative keratitis was one in 172 lens wearers per year, or 5.8/1000/year. This falls within the wide range of risk estimates (2.1/1000/year to 15/1000/year) proposed for extended lens wear in the civilian literature, and was less than predeployment worst-case planning.[3,4,10,13]

A questionnaire-based assessment of contact lens wear by the original Apache protocol subjects was overwhelmingly positive with a 98% endorsement of routine contact lens use in all operational environments.[8] Verbal feedback from the general aviation subjects within this report group was also highly positive. The most important aspect of this program is that, for the first time, contact lenses were successfully worn in combat by Army aircrew members under standardized, controlled observation conditions. Combat missions included attack, troop transport, equipment transport, surveillance, intelligence, and medical evacuation. The Apache radar interdiction mission into Iraq on Jan 16, 1991, consisted of several contact lens wearers, including the mission commander. Clearly, this "field test" of contact lenses successfully met its objectives.

CONCLUSION

Based solely on the clinical evaluations and subjective feedback, contact lens wear by Army aircrew is a viable alternative to spectacle wear. *In-situ* lens dehydration and secondary metabolic by-product trapping under the lens are hypothesized as the major source of clinical complications. It should be noted that the risk of ulcerative keratitis as a contact lens-related complication is very real. It must be addressed in the form of a strong educational and preventive medicine program with close optometric followup available as an integral part of the aviation organization. However, within the context of other health and mortality risks faced by Army aircrew in the routine performance of their military duties, the ulcerative keratitis risk has been sanctioned by the aviation community. Because of lens-fitting difficulties encountered with presbyopes and those with pre-existing medical conditions that contraindicated contact lens use, a certain portion of spectacle-wearing aircrew will not be able to successfully wear contact lenses. Consequently, routine contact lens wear represents a partial solution to Army aviation's spectacle incompatibility problem. Therefore, developmental hardware alternatives must be included in future system programming, or many Army air crewmembers will be prevented from performing certain flight duties.

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